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PHYSICS.—*Mass spectra of hydrocarbons.*[1] FRED L. MOHLER, National Bureau of Standards.

Mass spectra were first observed by J. J. Thompson by passing canal rays through transverse electric and magnetic fields. His discovery in 1913 (*1*) that there appeared to be two isotopes of neon led Aston (*2*) to much more elaborate experiments. For many years interest centered in discovery of new isotopes and precision atomic-weight measurements. Studies of molecular mass spectra were largely an American development. (*3*) The purpose was to study the mechanism of ionization of polyatomic molecules. Later Hipple (*4*) at Westinghouse and Washburn (*5*) of the Consolidated Engineering Corporation developed this type of mass spectrometer into an instrument suitable for chemical analysis of gas mixtures. The requirements for such an instrument are accurate automatic electrical recording and reliable reproducibility.

An important feature introduced by Bleakney was the ionization chamber in which the ions were produced. A beam of univelocity electrons traverses the ionization chamber and a magnetic field parallel to the beam keeps this beam centered while a small transverse electric field draws the ions produced out of the ionization chamber. The ions are then accelerated by a large electric field and bent by a magnetic field to give a mass spectrum.

The gas to be ionized enters the ionization chamber in a jet at very low pressure (about 10^{-4} mm), and fast pumps maintain a pressure of about 10^{-6} mm outside the ionization chamber. This insures ideally simple conditions. There is no appreciable accumulation of ionization products in the ionization chamber and there are no collisions between ions and gas molecules. As the applied voltage of the electron beam is increased, molecule ions first appear at about 10 to 12 volts. Then with increasing voltage, ions of various dissociation products are formed. Twenty-five or 30 volts are sufficient to produce almost every possible dissociation product of a hydrocarbon and, in the range 50 to 100 volts, the relative intensities of the molecule ion and the various dissociation products remain nearly independent of voltage. The resulting mass spectrum is a property of the molecule modified only slightly by instrumental factors.

In the Consolidated mass spectrometer the ions from the ionization chamber are accelerated by a variable electric field and bent through an arc of 180° by the field of a large magnet to reach a collecting electrode. After passing through the electric field V all the singly charged ions will have the same kinetic energy $1/2\ mv^2 = eV$ and light ions will have a high velocity and heavy ions a small velocity. The magnetic field exerts a force proportional to the velocity at right angles to the field and to the velocity. Ions of mass m and charge e will move on the arc of a circle of radius R defined by the relation $m/e = CH^2\ R^2/V$ where C is a constant, H is the magnetic field, and V the ion accelerating voltage. If V is gradually changed from high to low values, ions of different masses will successively reach the ion collector. The current reaching the collector is amplified and recorded by galvanometers on a moving sheet while $1/V$ changes at a uniform rate. Thus, the resulting record shows a series of peaks at the values of $1/V$ or m/e corresponding to the molecular weights of the compound and its dissociation products.

[1] Address of the retiring President of the Philosophical Society of Washington, January 17, 1948. Received March 17, 1948.

Fig. 1 is part of the mass spectrum record obtained with a Consolidated mass spectrometer of n butane, $CH_3 \cdot CH_2 \cdot CH_2 \cdot CH_3$. Four galvanometers with four ranges of sensitivity record the ion current. The upper trace records the galvanometer of highest sensitivity. Deflections of the other galvanometer traces are to be multiplied by 3, 10, and 30 to give deflections in terms of the upper trace. The parent peak, the undissociated molecule ion, is at mass 58 and a peak at 59 comes from molecules containing one C^{13} isotope. Then there are molecules which have lost from 1 to 10 hydrogen atoms. It is a remarkable fact that in a single ionization process all ten hydrogen atoms can be removed to give C_4^+. The most probable ionization process is losing CH_3 to give mass 43. Losing an additional CH_2 to give 29 is also probable.

One finds indeed every possible dissociation process consistent with the structural formula. Peaks at 25½ and 26½ come from doubly charged ions of mass 51 and 53. The small broad peaks are metastable ion transitions resulting from ions which dissociate after traversing the electric field. Hipple, Fox, and Condon (*6*) have studied and explained these metastable transition peaks.

The use of mass spectra for chemical analysis involves the direct comparison of the mass spectrum of an unknown with the spectra of pure compounds and an important project of the Mass Spectrometry Section is compiling mass spectra of pure compounds.

To show characteristics of the mass spectra of hydrocarbons it is convenient to use a greatly simplified picture in which only peaks greater than 2 percent of the maximum peak are included. The maximum peak is uniformly given a height of 100. First are shown spectra of saturated hydrocarbons of formula $C_n H_{2n+2}$. Fig. 2 shows some of these.

In methane the most probable process is ionization without dissociation. Ionization

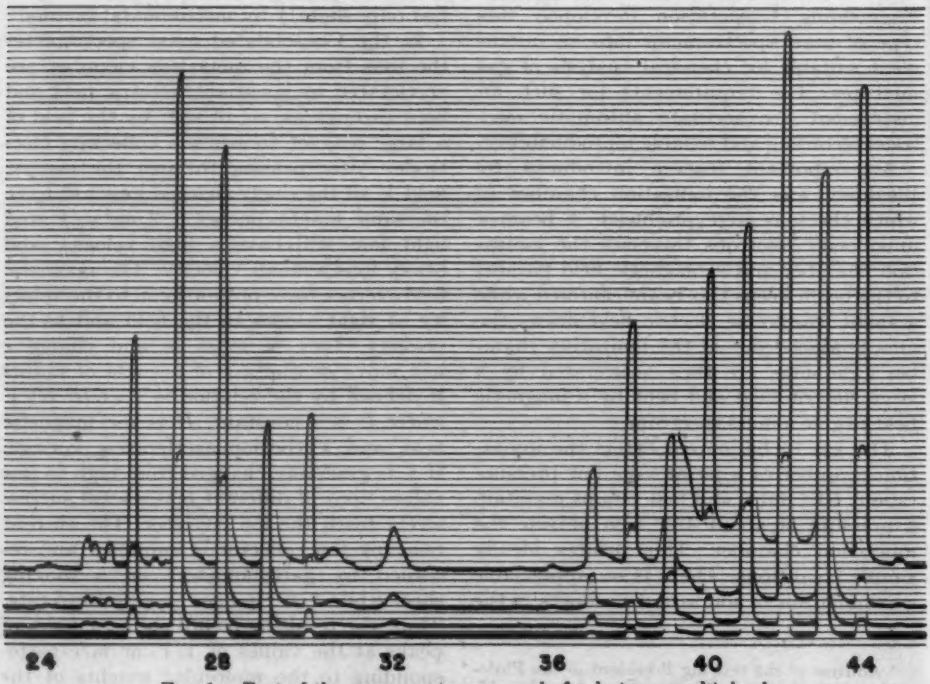


FIG. 1.—Part of the mass spectrum record of n-butane as obtained by a Consolidated mass spectrometer.

with removal of one hydrogen atom is probable but removal of H^+ is improbable and this is true in all hydrocarbons. In ethane the most probable ionization process involves removal of two hydrogen atoms. Production of CH_3^+ is relatively improbable here and in all hydrocarbons except methane. In propane and the two butanes loss of CH_3 is the most probable ionization process.

It is a useful property of the structure of saturated hydrocarbons that the parent peak of each hydrocarbon is characteristic of that hydrocarbon and can not be produced as a dissociation product of other compounds. The other mass peaks recur in spectra of heavier compounds. This is very convenient for the purpose of chemical analysis.

There are two isomers of butane and the different structures give markedly different spectra. One difference between n-butane and iso-butane is that one can not break iso-butane in half without first rearranging the hydrogen atoms. A peak at mass 29 is found so this rearrangement must occur before dissociation. Such rearrangements are common in more complicated molecules. The parent peak is much smaller in iso-butane and it is a general rule that molecules with side chains have smaller parent peaks than the normal molecule.

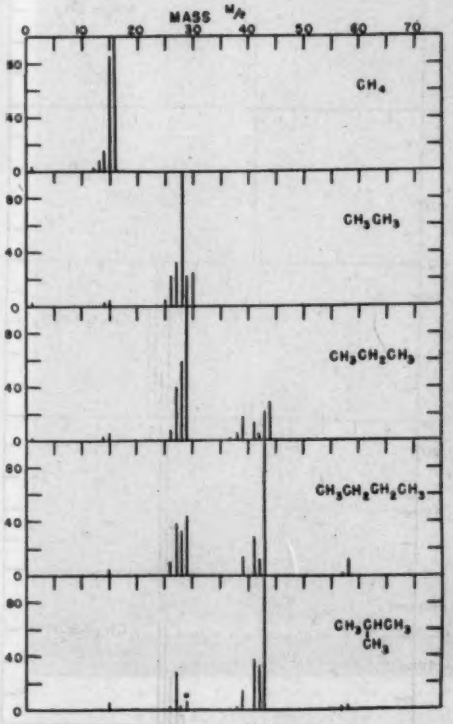


FIG. 2.—Mass spectra of methane, ethane, propane, and two butanes.

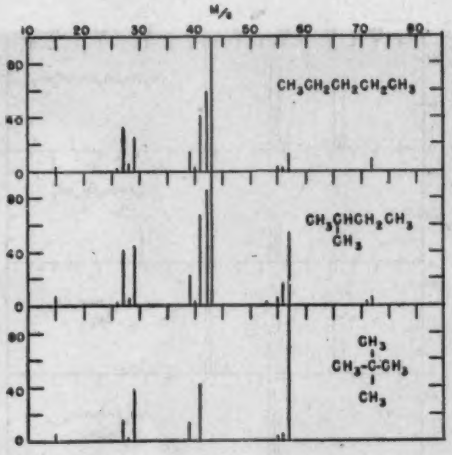


FIG. 3.—Mass spectra of pentanes.

Fig. 3 shows spectra of the three isomers of pentane. In normal and iso-pentane losing CH_3+CH_3 is the most probable process. In neopentane losing CH_3 is most probable and the parent peak is only a few hundredths of a percent. Losing two CH_3 radicals is quite improbable and the loss of CH_3+CH_4 involving breaking of three bonds is quite probable. The peak at $C_2H_5^+$ is large although this requires a rearrangement of hydrogen atoms before dissociation, as in iso-butane. Here the spectrum gives little clue as to the structure of the molecule.

There are five hexanes shown in Fig. 4 and these give five very different mass spectra. Many of the features of these spectra can be described qualitatively by the statement that there is a tendency to dissociate at either side of each side chain. Normal hexane like normal pentane loses C_2H_5 most readily. In 2-methyl-pentane, loss of one or three carbon groups is preferred, while in 3-methyl-pentane, loss of

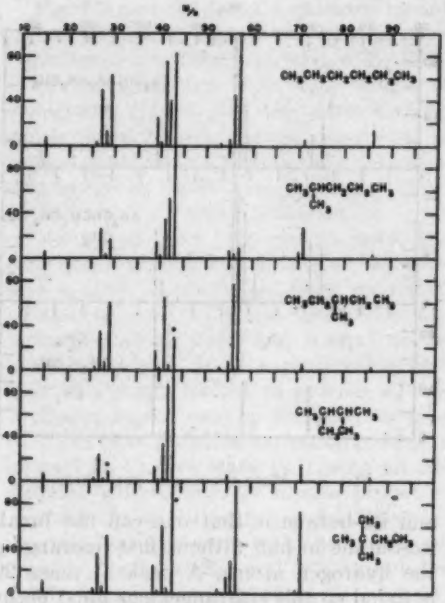


FIG. 4.—Mass spectra of hexanes.

C_3H_5 is again preferred. In 2,3-dimethyl-butane, loss of one and three are preferred while in 2,2-dimethyl-butane, one and two are preferred. In the last case, however, the most probable ionization process is breaking in half to give 43^+ although this involves a rearrangement of hydrogen atoms. Peaks involving rearrangement are also noted at 43 in 3-methyl-pentane and at 29 in 2,3-dimethyl-butane. We know that these cases involve rearrangement because the original structure does not yield such masses but obviously rearrangement may occur in other cases where it is indistinguishable from simple dissociation.

Our measurements include the nine isomers of the heptanes and the 18 octanes. All these show a great variety of mass spectra depending on the structure of the molecules. The tendency to dissociate on either side of a side chain is again found except in cases where rearrangements give ions which would not be expected on the basis of the molecular structure.

Fig. 5 shows some unsaturated molecules with double or triple bonds. In ethylene the parent peak is the maximum peak, while in ethane it is about 25 percent of the maximum. In acetylene the parent peak is by far the largest peak. In propylene the parent peak is not the largest, but the whole C three group of ions is much larger than in propane. Propylene always loses CH_2 rather than CH_2 and this is true of most of the unsaturated molecules. There are two isomers of C_3H_4, propadiene and methyl-acetylene, and their mass spectra are almost exactly alike in spite of the difference in structure. It seems very probable that in this case first a molecule ion is formed and then the hydrogen atoms are redistributed to give identical ions from both isomers.

Fig. 6 shows some unsaturated C four molecules. There are four butene isomers and they all give mass spectra similar to

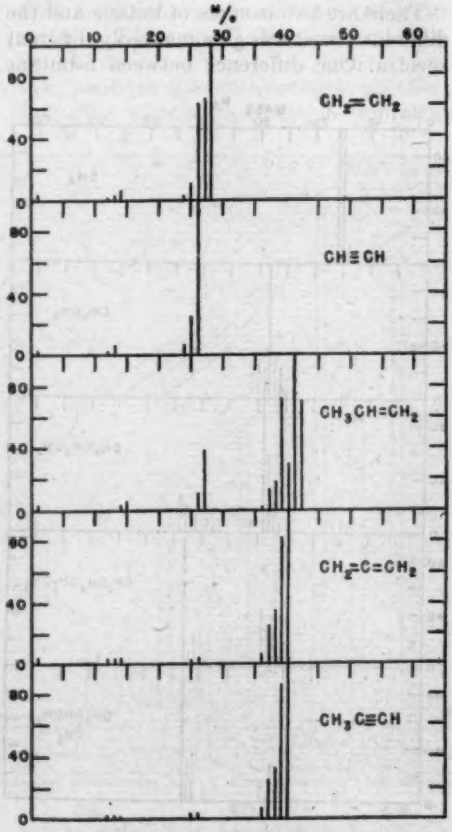
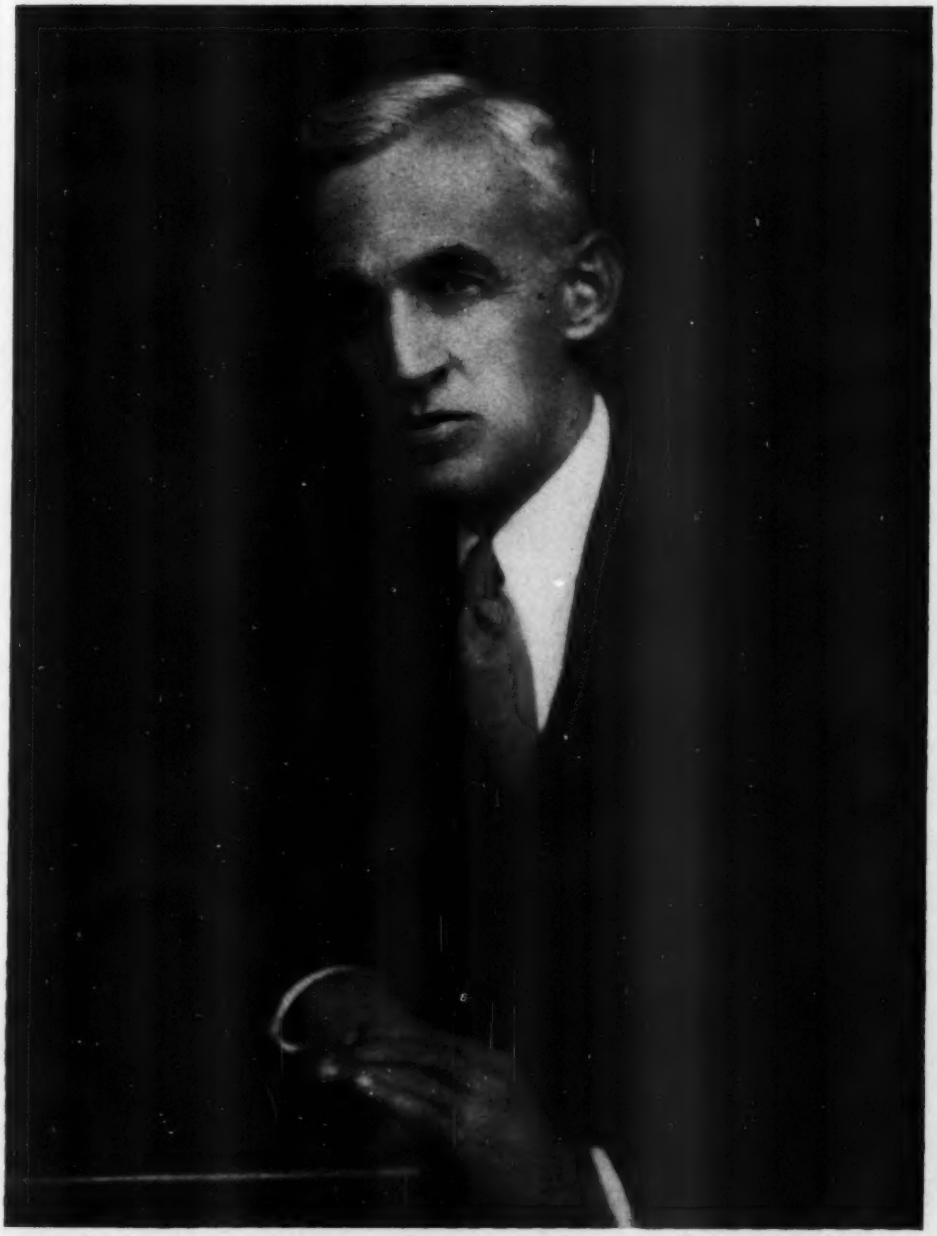


FIG. 5.—Mass spectra of ethylene, acetylene, propylene, propadiene, and methyl acetylene.



FRED L. MOHLER, president of the Philosophical Society of Washington, 1947

the 1-butene spectrum shown in the figure. 2-butene, $CH_3-CH=CH-CH_3$, has a cis and a trans form depending on whether the two central hydrogens are on the same side or opposite sides of the chain. The mass spectra are nearly identical, the most conspicuous difference being that the mass 29 peak is 15.5 percent of the maximum in the cis compound and 19.8 percent in the trans compound. These two molecules cannot give a 29^+ ion without a rearrangement of hydrogen atoms.

There are four isomers of C_4H_8 and the mass spectra show differences of a rather unexpected nature. The most probable ionization process in $CH_2:CH\cdot CH:CH_2$ is loss of mass 15 which involves a double dissociation while in the other isomers which can lose 15 in a simple dissociation this transition is less probable. Also, the mass 28 peak is largest in 1,3-butadiene where production of 28^+ involves a rearrangement of hydrogen atoms.

The unsaturated hydrocarbons show several characteristics as a class. The parent peaks are larger than for saturated compounds and larger for doubly unsaturated compounds than for mono-olefins. Ionization by loss of CH_2 is very improbable even where both terminal radicals are CH_2. Both properties reflect the fact that the unsaturated bonds are stronger than the saturated bonds. Mass spectra of unsaturated molecules are also much less sensitive to structural differences among different isomers than is the case with saturated molecules. This indicates that rearrangements of hydrogen atoms in the molecule ion occur more readily in the unsaturated molecules. It may seem surprising that there are any rearrangements in saturated hydrocarbons and it will be of interest to study mass spectra with deuterium substituted at one position in the molecule and see where it appears in the mass spectrum.

On the basis of momentum considerations it must be assumed that electron collisions always produce molecule ions and that these ions may be left in a highly excited state and subsequently dissociate spontaneously to give the great variety of ions observed in the mass spectrum. I have referred before to small wide peaks in the

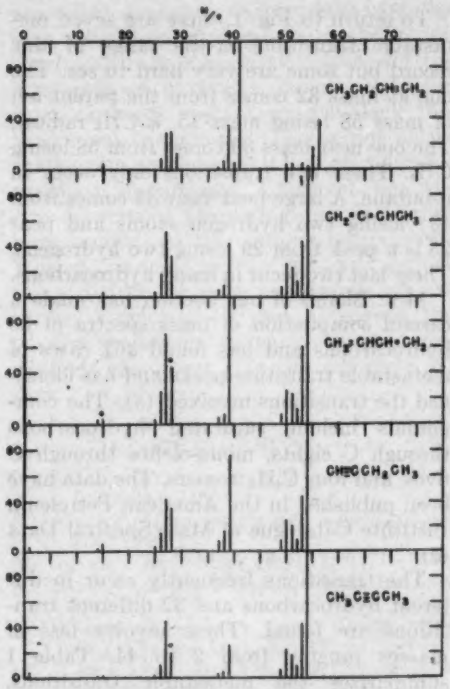


FIG. 6.—Mass spectra of butene-1, butadienes, and butynes.

mass spectrum that arise from ions which dissociate after they have traversed the electric field. Because of this phenomenon of delayed dissociation we can obtain direct experimental evidence as to some of the dissociation processes which occur.

The apparent mass m_a of an ion which dissociates immediately after traversing the electric field is

$$m_a = m_f^2/m_i$$

where m_i is the initial mass and m_f the final mass of the ion (*6*). Because the ions dissociate over a range of positions the peaks are wide. The dissociating ions are presumably metastable ions with a life of the order of 10^{-6} seconds (*7*). As m_f and m_i are integers equal to or less then the molecular weight the numerical value of m_a is sufficient to determine both m_f and m_i. An important aid in finding m_f and m_i is a qualitative intensity rule that the mass peaks corresponding to m_f and m_i are always fairly large peaks in the mass spectrum.

To return to Fig. 1, there are seven metastable transitions in the range of this record but some are very hard to see. The one at mass 32 comes from the parent ion of mass 58 losing mass 15, a CH_3 radical. The one near mass 30 comes from 58 losing CH_4. These two transitions only occur in n-butane. A large peak near 39 comes from 43^+ losing two hydrogen atoms and near 25 is a peak from 29 losing two hydrogens. These last two recur in many hydrocarbons.

Mrs. Bloom of our Section has made a careful compilation of mass spectra of 56 hydrocarbons and has found 362 cases of metastable transition peaks and has identified the transitions involved (*8*). The compounds include saturated hydrocarbons through C eights, mono-olefins through C fives, and four C_4H_8 isomers. The data have been published in the American Petroleum Institute Catalogue of Mass Spectral Data (*9*).

The transitions frequently recur in different hydrocarbons and 32 different transitions are found. These involve loss of masses ranging from 2 to 44. Table 1 summarizes the metastable transitions. Loss of mass 2 is by far the most common type of metastable transition and it appears in nearly all cases where there are two large peaks differing by two mass units. Losses of masses 1 or 3 are never observed.

It is also significant that there are no metastable transitions involving loss of CH_2 as this is a structural unit in most hydrocarbons and large peaks often fall at intervals of 14.

Loss of CH_3 is only observed from parent ions and is a comparatively infrequent phenomenon. CH_4 is not a structural unit and loss of 16 involves a double dissociation. The loss from the ion 57^+ recurs in 30 of the 40 saturated hydrocarbons.

Loss of C_2H_3 seems to be a unique property of the 55^+ ion and recurs in most of the hydrocarbons. The loss of C_2H_3 occurs only when the butadienes and butyne-2 split in half. It is of interest that the unsymmetrical molecule $CH_2=C=CH-CH_3$ splits in half although this requires a rearrangement before splitting. C_2H_4 in the form $CH_2 \cdot CH_2$ or $CH \cdot CH_3$ is a structural unit of many saturated molecules and the 2 metastable transitions recur in many of them. In this case, the terminal CH_3 radical must first be removed from the initial ion.

The loss of mass 29 comes from loss of the structural unit $CH_2 \cdot CH_3$ and includes the terminal radical as is shown by the fact that it comes from parent ions. Loss of mass 30 comes from losing two CH_3 radicals from the parent ion and necessarily involves a double dissociation.

The mass C_3H_6 can be $CH_2 \cdot CH_2 \cdot CH_2$ or can involve methyl side chains, but like C_2H_4 it will never come from parent ions. Of course, it can only come from rather large molecules. Loss of mass 44 from the parent mass of 3 heptanes is perhaps doubtful. We are not certain that there is not an alternative explanation. It involves a double dissociation, removal of mass 43 and one hydrogen.

This looks very complicated, and I have given it in detail to show that dissociation of ions does indeed involve many alternative processes. If the initial metastable ion is the parent ion this means that the molecule ion traverses the electric field and then dissociates. When the initial ion is not the parent ion then the dissociation takes place in at least two stages. The initial metastable

TABLE 1.—SUMMARY OF METASTABLE TRANSITIONS

Mass lost		Occurrence
2	2H	8 transitions in all hydrocarbons except methane.
15	CH_3	7 transitions from parent ions of 13 unsaturated and 5 saturated hydrocarbons.
16	CH_4	$55^+ \rightarrow 39^+ + 16$ in pentenes. $57^+ \rightarrow 41^+ + 16$ in 30 saturates. $58^+ \rightarrow 42^+ + 16$ in n-butane.
26	C_2H_2	$55^+ \rightarrow 29^+ + 26$ in 41 hydrocarbons.
27	C_2H_3	$54^+ \rightarrow 27^+ + 27$ in 3 isomers of C_4H_6.
28	C_2H_4	$71^+ \rightarrow 43^+ + 28$ in 21 saturates. $85^+ \rightarrow 57^+ + 28$ in 14 saturates.
29	C_2H_5	3 transitions from parent ions of pentenes, n-hexane, and 3 octanes.
30	C_2H_6	4 transitions from parent ions of 12 saturated hydrocarbons.
42	C_3H_6	$85^+ \rightarrow 43^+ + 42$ in 19 heptanes and octanes. $99^+ \rightarrow 57^+ + 42$ in 17 octanes.
44	C_3H_8	$100^+ \rightarrow 56^+ + 44$ in 3 heptanes.

ion is formed by dissociation within the ionization chamber, then it passes through the electric field and dissociates again. Sometimes large structural units are broken off in a single dissociation; in other cases at least two bonds must be broken in the delayed dissociation as in losing two CH_3 radicals or CH_4.

The metastable transitions account for only a small fraction of all the dissociations. Hipple (7) has made quantitative estimates in the case of n-butane. The parent ion gives rise to two metastable transitions with loss of masses 15 and 16. The life of each excited state is about 2×10^{-6} sec and initially at time zero not over 10 percent of the 58^+ ions are in the excited state or states which give rise to these transitions. Now the 58^+ ions account for only about 4 percent of all the n-butane ions. Ninety-six percent of all the ions dissociate immediately or very quickly, about 3.6 percent become stable 58^+ ions and 0.4 per cent fall into the metastable states. This is probably a typical case as far as orders of magnitude are concerned.

What I have said has been largely descriptive and probably seems like little more than a catalog of empirical facts. However, this is largely a matter of viewpoint. As I pointed out in the introduction, these mass spectra are a molecular property and are somewhat analogous to intensities in molecular absorption spectra but in absorption spectra there is a theoretical basis for the interpretation of results. In spite of all the work on mass spectra we still lack this theoretical background. This is not only a challenging problem but it is of considerable practical importance. Chemical analysis now depends on comparing unknowns with pure samples of the various components. It would be very useful if we could deduce the structure of pure compounds of unknown structure. Beyond C sevens the possibilities become so many that empirical methods can never give the complete answer.

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(9) AMERICAN PETROLEUM INSTITUTE, Research Project 44.

BOTANY.—*New species of* Achaetogeron (*Compositae*) *from Mexico.*[1]

ESTHER L. LARSEN, Crown Point, Indiana. (Communicated by S. F. BLAKE.)

The new species here described were discovered some years ago when the genus *Achaetogeron* was being studied together with several related genera of the tribe Astereae. The work was done at the Missouri Botanical Garden. The following abbreviations are used for herbaria cited: M = Missouri Botanical Garden; NY = New York Botanical Garden; Phil = Academy of Natural Sciences, Philadelphia; US = U. S. National Herbarium.

Achaetogeron filiformis Larsen, sp. nov.

Annuus 15–45 cm altus; caules tenues juventate simplices maturitate diffuse ramosi foliosi patenti-hirsuti; folia obovata ad obovato-spathulata pinnatifida 0.5–4 cm longa, lobis obtusis apiculatis strigosis; folia suprema bracteiformia oblonga integra; pedunculi filiformes 1.5–2.5 cm longi infra capitulum dense patenti-hirsuti; capitula 0.7–1 cm diam.; phyllaria 2–3-seriata lineari-lanceolata acuminata glandulari-puberula basi hirsuta; radii albi vel caerulei supra discum arcte circinnati; pappus inconspicuus coroniformis laceratus, in floribus radii interdum etiam setis paucis donatus; achenia pubescentia pilis apice rectis vel obscure bidentatis.

TAMAULIPAS: Vicinity of Tampico, alt. 15 m, March 10–April 19, 1910, *E. Palmer* 249 (type, M, also US); vicinity of La Barra, 8 km east of Tampico, at sea level, February 1–8, 1910, *E. Palmer* 281 (M, US); en route

[1] Received March 23, 1948.

from San Luis Potosí to Tampico, December 1878 to February 1879, *E. Palmer* 1089 (US). VERACRUZ: Vicinity of Panuco, April 20–25, 1910, *E. Palmer* 356 (US).

The filiform peduncles, small heads, and circinate rays which scarcely exceed the disc distinguish this species.

Achaetogeron fisheri Larsen, sp. nov.

Herbaceus 20–45 cm altus ubique strigosus, ramis adscendentibus e caule decumbente sublignoso; folia caulina sessilia alte pinnatisecta 1–3 cm longa lobis 3–7 lineari-lanceolatis obtusis, folia suprema saepius integra linearia; pedunculi 2–4 cm longi strigosi; capitula 2–2.5 cm diam. (radiis inclusis); involucri 2–seriati 0.5 cm alti phyllaria lineari-lanceolata acuminata glanduloso-puberula et strigosa, margine scariosa; pappus annularis laceratus inconspicuus cum setis caducis interioribus; achenia basi callosa pubescentia; pilis bidentatis.

STATE OF MEXICO: Amecameca, alt. 2,648 m, July 29, 1924, *Fisher* (M, No. 914802 type); Amecameca, alt. 2,676 m, July 29, 1924, *Fisher* 220 (US). PUEBLA; Teutla, October 1913, *Salazar* (US); Manzanilla, vicinity of Puebla, November 24, 1908, *Arsène* 10184 (US).

The subpinnatifid leaves and a pappus crown so reduced as to be nearly lacking are characteristic.

Achaetogeron sophiaefolius Larsen, sp. nov.

Perennis 30–60 cm altus; caules plures e basi sublignoso ramosi striati patenti-hirsuti et subglandulari-puberuli; folia elliptica ad ovata, pinnatisecta vel bipinnatisecta inferiora petiolata usque ad 9 cm longa pilis longis multicellularibus appressis pubescentia et minute glandulari-puberula, segmentis ultimis obtusis, superiora sensim reducta sessilia, suprema bracteiformia; pedunculi 1.5–3 cm longi dense appresse pubescentes; capitula terminalia solitaria 2–2.5 cm diam. (radiis inclusis); involucri 1–1.2 cm diam. phyllaria 2-seriata 4 mm longa lineari-lanceolata acuminata glandulosa et parce hirsuta pilis multicellularibus, margine membranacea; pappus minutus coroniformis laceratus cum setis paucis caducis interioribus; achenia basi callosa pubescentia pilis apice rectis vel dentatis.

DURANGO: City of Durango and vicinity, April–November 1896, *E. Palmer* 158 (M, No. 123017 type, NY, US).

A relatively coarse plant with conspicuously bipinnatisect leaves, which are pubescent with long appressed multicellular hairs.

Achaetogeron pringlei Larsen, sp. nov.

Herbaceus erectus ca. 65 cm altus ubique glandulari-puberulus et patenti-hirsutus; folia caulina sessilia alte pinnatisecta lobis ca. 5–9 linearibus vel lineari-spathulatis obtusis utrimque sparse villosa margine ciliata; folia inflorescentiae lineari-lanceolata integra vel interdum lobata sensim reducta, suprema ca. 1 cm longa; pedunculi 1.5–2.5 cm longi dense glandulari-puberuli pilis sparsis intermixtis; capitula 1.5–2.5 cm diam.; involucri 2-seriati phyllaria lineari-lanceolata acuminata anguste membranaceo-marginata glandulari-puberula et sparse pilosa; radii numerosi albi saepe reflexi; flores disci numerosi; pappus minutus coroniformis laceratus cum setis paucis interioribus caducis; achenia anguste obovata basi minute callosa pubescentia pilis apice rectis vel bidentatis.

CHIHUAHUA: Cool slopes, Sierra Madre, October 10, 1888, *Pringle* 1625 (M, type); cool slopes, foothills of the Sierra Madre, October 11, 1887 *Pringle* 1272 (Phil). PUEBLA: Santa María de Zacatepec, vicinity of Puebla December 1908, *Arsène* (US).

Distinguished by deeply pinnatisect, sparingly villous leaves and a relatively finer habit than *A. sophiaefolius*.

Achaetogeron polycephalus Larsen, sp. nov.

Herbaceus 1m altus et ultra (basi inviso) ubique strigosus et minute glandulari-puberulus; caulis supra valde ramosus aetate glabratus; folia caulina majora oblanceolata sessilia prope apicem serrata usque ad 5 cm longa 1.5 cm lata, minora valde reducta integra; pedunculi 1–4 cm longi striati strigosi et minute glandulari-puberuli; capitula 2–3 cm diam. (radiis inclusis); involucri 2-seriati phyllaria lineari-lanceolata acuminata anguste membranaceo-marginata minute glandulari-puberula basi patentipilosa margine angusto membranaceo leviter lacerato; radii numerosi albi; pappus minutus annularis laceratus cum paucis setis interioribus; achenia basi callosa dense pubescentia pilis apice rectis vel bidentatis.

DURANGO: San Ramón, April 21–May 18, 1906, *E. Palmer* 52 (M, type).

A profusely branching, strigose-pubescent

plant with serrate leaves and many scattered heads.

Achaetogeron corymbosus Larsen, sp. nov.

Herbaceus 20–40 cm altus dense breviterque cinereo-hirsutus et minute glandulari-puberulus; caules erecti ramosi ramis apice corymboso-ramosis; folia caulina oblanceolata sessilia supra serrata 5 cm longa 1.5 cm lata, superiora ad bracteas sensim reducta; folia infima non visa; pedunculi 0.5—1 cm longi; capitula 1–1.5 cm diam. (radiis inclusis); involucri 2-seriati phyllaria lineari-lanceolata acuminata minute glandulari-pubescentia et sparsissime hirsuta, margine angusto scarioso leviter lacerato; radii albi; pappus minutus coroniformis vel annularis laceratus cum setis paucis caducis interioribus; achenia basi late callosa dense pubescentia pilis longis apice rectis.

JALISCO: Canyons, moist rocks, Tuxpan, February 1904, *Purpus* 527 (G, type).

The serrate leaves, crowded corymbs, and cinereous aspect are characteristic.

Achaetogeron garciae (Blake) Larsen, comb. nov.

Bellis garciae Blake, Contr. U. S. Nat. Herb. 22: 593. 1924.

Still known only from the type, *P. Ibaña García* 310 (U. S. Nat. Herb. 1032782) from the State of Durango, alt. 100 m.

ENTOMOLOGY.—*Notes and descriptions of Nearctic Hydroptilidae (Trichoptera).*[1]

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In the caddisflies of the family Hydroptilidae there undoubtedly exists a number of genera that bear their closest relationship with forms known from other regions and with which they have not yet been associated. Two such cases are outlined in this paper, and in each the geographic limits of the genera involved are extended into another continent. During the investigation of these cases some interesting morphological considerations have arisen, and as a result a few suggestions regarding terminology are made in this paper.

I am greatly indebted to Dr. G. T. Riegel, University of Illinois, and to Dr. H. K. Gloyd, Chicago Academy of Sciences, for making material available to me for study, and to Dr. D. G. Denning for the loan of type material of some of the species studied. Types of new species described in this paper are deposited in the collection of the Illinois Natural History Survey.

TERMINOLOGY

In reviewing the terminology I have used for parts of the male genitalia of Hydroptilidae, one change and one addition seem indicated in the interests of clarity and structural identification.

Subgenital plate.—In most genera of Hydroptilidae there is a variously shaped, mesal structure usually occurring above or between the claspers. In *Hydroptila*, Fig. 6, *sp*, and *Neotrichia* this structure is platelike and bears at its apex a pair of setae. In *Oxyethira* and *Stactobiella* what appears to be this same structure is heavily sclerotized, frequently arched, and assumes a variety of shapes in different species; in these two genera I have heretofore called this structure the tenth tergite (Ross, 1938, 1944). The tenth tergite, however, must be above the aedeagus, whereas in the structure in question, Fig. 1*A*, *sp*, it is situated below the aedeagus. It may be a sort of guide for the aedeagus or it may assist in the coupling action during copulation. Because it lies below the aedeagus and because its exact homology is obscure, I am proposing that this plate be called the *subgenital plate*.

Bracteole.—In quite a number of Hydroptilidae, especially in *Stactobiella*, there occurs a structure associated with the area dorsad of the base of each clasper. In some cases, Fig. 1, *br*, this appears as a small structure at the base of each clasper, in others, Fig. 2, *br*, the structure is larger and more conspicuous than the clasper and probably usurps its function. For this I propose the term *bracteole*. Here again the homology is difficult to determine, but I believe that the term will be a useful one for purposes of taxonomic description.

[1] Received March 8, 1948.

Genus **Stactobiella** Martynov

Stactobiella Martynov, Pract. Ent. 5: 58. 1924. (Genotype, monobasic, *Stactobia ulmeri* Siltala.)

Tascobia Ross, Bull. Illinois Nat. Hist. Surv. 23: 124. 1944. (Genotype, by original designation, *Stactobia palmata* Ross.) *New synonymy.*

Comparing Nearctic species of this genus with illustrations of Palearctic species shows that not only are the two genera synonymous but also that two Nearctic forms each have their closest known relative in the Palearctic fauna. *S. palmata* (Ross) is very similar to Martynov's illustrations of *biramosa* Martynov, the former having the claspers short and ovate, constricted at base, and the stalked process tridentate, the latter having the claspers slightly longer and parallel-sided, and the stalked process bidentate. In each the aedeagus is simple and tubular. The Nearctic species *delira* (Ross) is similar to the Palearctic *ulmeri* (Siltala) and *risi* (Felber), especially in regard to the curved, fingerlike subgenital plate, but exhibits marked differences in the shape of each structure. The Nearctic *brustia* Ross is not allied closely to any of the other species and forms a species complex of its own. Thus, not only is *Stactobiella* as a genus Holarctic in distribution, but two of its three component phylogenetic units are truly Holarctic also.

To assist in identifying these species, a key is given to the males of these six species, which comprise the known world fauna of the genus. I have taken characters of the Palearctic forms from illustrations in the literature, cited in the key.

KEY TO SPECIES OF STACTOBIELLA MALES

1. Claspers apparently fused to form a ventral plate bearing three whiskerlike brushes of setae; aedeagus with apex curved and bent into shape of a crook (Ross, 1938, p. 115, fig. 22). Nearctic (Wyoming) ..... *brustia* (Ross)
   Claspers not fused, either elongate or biscuit-shaped 2
2. A curved process, the bracteole, arising above each clasper, longer than the clasper and divided at apex into two or three fingerlike branches, Fig. 2; subgenital plate short and wide 3
   Bracteole represented by only a small process associated with a lateral clump of setae, clasper long, parallel-sided or tapering to apex; subgenital plate long and fingerlike, often curved or angled, Fig. 1 4
3. Bracteole having apex divided into two "fingers" (Martynov, 1934, p. 159, fig. 105). Palearctic (Russia) ..... *biramosa* Martynow
   Bracteole having apex divided into three "fingers," Fig. 2. Nearctic (central U. S. A.) ..... *palmata* (Ross)
4. Apical portion of aedeagus divided into one mesal and two lateral lobes, Fig. 1*A*. Nearctic (northcentral U. S. A.) ..... *delira* (Ross)
   Apical portion of aedeagus tubular, much as in Fig. 2 5
5. Apical margin of clasper truncate and slightly oblique (Felber, 1908, p. 721, fig. 2). Palearctic (Switzerland) ..... *risi* (Felber)
   Apical margin of clasper rounded, the clasper tip narrow (Martynov, 1934, p. 159, fig. 103). Palearctic (northern Europe) ..... *ulmeri* (Siltala)

Genus **Oxyethira** Eaton

Argyrobothrus Barnard, Trans. Roy. Soc. South Africa 21: 392. 1934. (Genotype, monobasic, *A. velocipes* Barnard.) *New synonymy.*

Barnard's illustrations of pupal case, venation, and genitalia of both sexes leave no doubt that *Argyrobothrus velocipes* is a typical member of *Oxyethira*. The genus as such has not been recorded previously from central or southern Africa.

Oxyethira arizona, new species

The wide, curved lateral process of the aedeagus and the long, ventral internal projection of the base of the ninth segment show a relationship of this species with *pallida* (Banks) and *maya* Denning, but *arizona* differs from both of these in the straight apical portion of the aedeagus (this part is angled and twisted in *pallida* and *maya*) and the elongate lateral processes of the eighth tergite.

Male.—Length from front of head to tip of wings, 2.5 mm. Color entirely pallid or straw color, with an annulation of a darker shade on some segments of the antennae and some darker areas on the front wings. General structure typical for genus. Seventh sternite with a sharp curved apical process. Genitalia as in Fig. 4. Eighth tergite divided into a pair of lateral lobes, the lower margin of each produced into a long, smooth, sharp process, the left one curved dorsad at tip, as shown, the right one curved slightly ventrad; the base of each lobe bears abundant long setae, but the projecting portion is without vestiture. Eighth sternite forming the lateral and ventral part of a ring, trapezoidal from lateral view, the apical margin gently curved on the meson. Ninth tergite membranous. Subgenital plate moderately

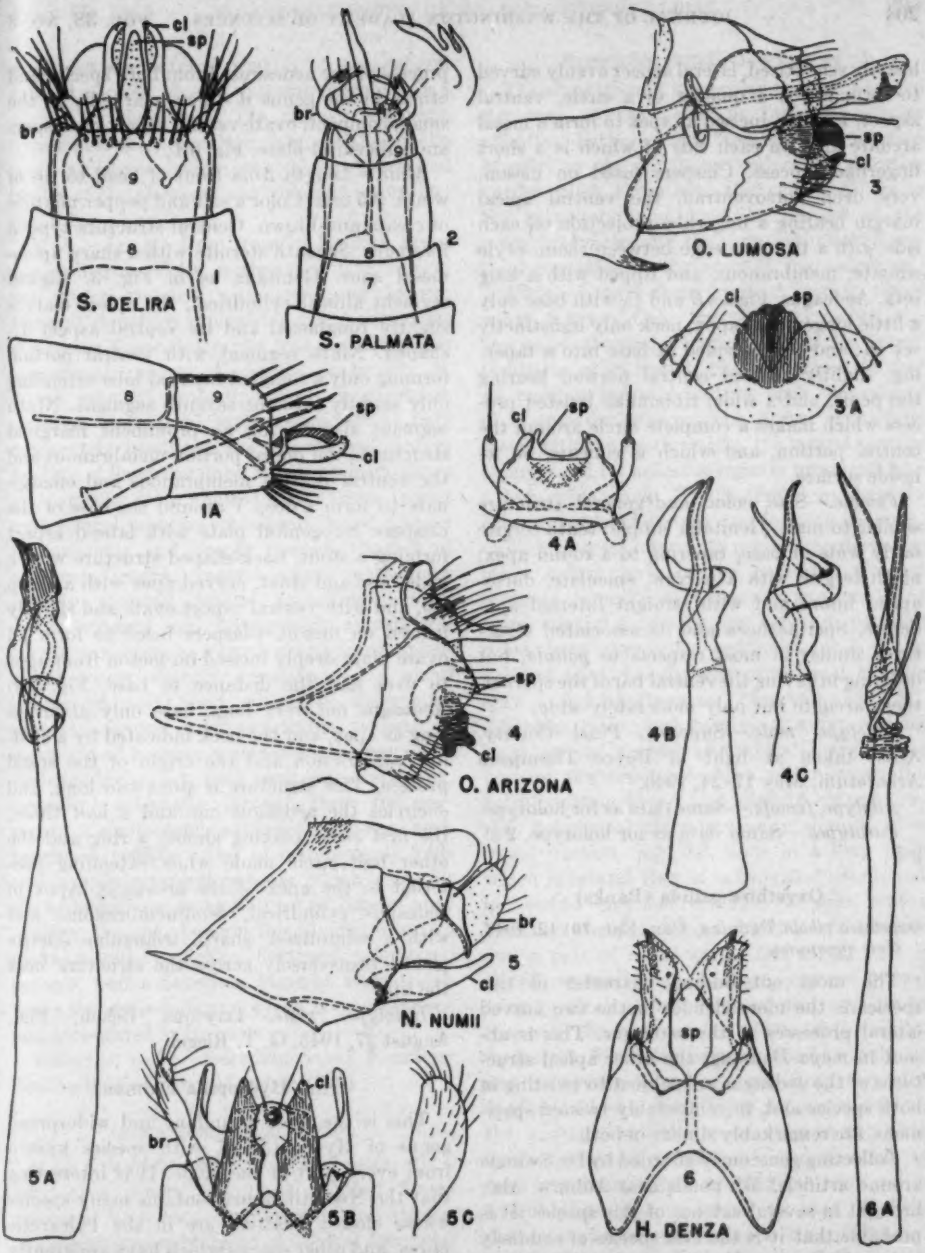

FIG. 1.—*Stactobiella delira*, male genitalia, ventral aspect; 1*A*, same, lateral aspect. FIG. 2.—*Stactobiella palmata*, male genitalia, ventral aspect. FIG. 3.—*Oxyethira lumosa*, male genitalia, lateral aspect; 3*A*, apical portion of male genitalia, ventral aspect. FIG. 4.—*Oxyethira arizona*, male genitalia, lateral aspect; 4*A*, claspers and associated structures, ventral aspect; 4*B* aedeagus; 4*C*, aedeagus as seen at right angles to long axis of 4*B*. FIG. 5.—*Neotrichia numii*, male genitalia, lateral aspect; 5*A*, aedeagus, 5*B*, claspers and associated structures, ventral aspect; 5*C*, bracteole. FIG. 6.—*Hydroptila denza*, male genitalia, ventral aspect; 6*A*, aedeagus. Abbreviations: *br*, bracteole; *cl*, clasper; *sp*, subgenital plate.

heavily sclerotized, lateral aspect evenly curved to form about a quarter of a circle, ventral aspect, Fig. 4*A*, incised at apex to form a mesal arcuate area on each side of which is a short fingerlike process. Claspers fused on meson, very deep dorsoventrad, the ventral apical margin bearing a fingerlike projection on each side with a truncate edge between them. Style sinuate, membranous, and tipped with a long seta. Aedeagus, Figs. 4*B* and *C*, with base only a little longer than apex; neck only indistinctly set off: and apex divided at base into a tapering, slightly twisted central portion bearing the penis, and a wide, ribbonlike twisted process which makes a complete circle around the central portion, and which is concave on its inside surface.

Female.—Size, color, and general structure similar to male. Genitalia simple; tenth tergite fairly wide at base, tapering to a round apex; ninth tergite with a narrow, spiculate, dorsoapical hump and with straight internal apodemes. Spermatheca and its associated structures similar in most respects to *pallida*, but differing in having the ventral bar of the spermatheca arcuate but only moderately wide.

Holotype, male.—Superior, Pinal County, Ariz., taken at light in Boyce Thompson Arboretum, May 17–24, 1946.

Allotype, female.—Same data as for holotype.

Paratypes.—Same data as for holotype, 2 ♂, 9 ♀.

Oxyethira pallida (Banks)

Oxyethira cibola Denning, Can. Ent. 79: 12. 1947. *New synonymy.*

The most outstanding character of this species is the more slender of the two curved lateral processes of the aedeagus. This is absent in *maya* Denning; the other apical structures of the aedeagus are subject to twisting in both species and, in comparably twisted specimens, are remarkably similar in both.

Collecting generously afforded by Dr. Swingle around artificial fish ponds near Auburn, Ala., brought in several catches of this species. It is probable that it is the first species of caddisfly to invade these ponds after they are filled.

Oxyethira lumosa, new species

This species is most closely related to *grisea* Betten and *novasota* Ross on the basis of simple eighth segment and the long, curled spiral process of the aedeagus. From both species and others in the genus it differs markedly in the small, compact, ovate ventral aspect of claspers and subgenital plate, Fig. 3*A*.

Male.—Length from front of head to tip of wings, 2.5 mm. Color a salt and pepper mixture of cream and brown. General structure typical for genus. Seventh sternite with a sharp apicomesal spur. Genitalia as in Fig. 3. Eighth segment almost cylindrical, the apical margin slightly roughened and its ventral aspect U-shaped. Ninth segment with ventral portion forming only a rounded internal lobe extending only slightly into the seventh segment. Ninth segment also having no prominent marginal structures, the dorsal portion membranous and the ventral portion membranous and emarginate to form a deep V around the base of the claspers. Subgenital plate with lateral aspect forming a stout, hook-shaped structure with a wide base and stout, curved apex with a sharp tip, and with ventral aspect ovate and slightly incised on meson. Claspers fused to form an ovate plate deeply incised on meson from apex to over half the distance to base, Fig. 3*A*. Aedeagus not very long, base only about as long as apex, and the neck indicated by a shallow constriction and the origin of the spiral process. This structure is stout and long, and encircles the aedeagus one and a half times, the first circle making almost a ring and the other half circle made while extending posteriad to the apex of the aedeagus. Apex of aedeagus cylindrical, semimembranous, and with a sclerotized, sharp, triangular sclerite placed transversely across the structure near the tip.

Holotype, male.—Daytona Beach, Fla., August 27, 1945, G. T. Riegel.

Genus **Hydroptila** Dalman

This is the most abundant and widespread genus of Hydroptilidae, with species known from every part of the globe. It is interesting that the Nearctic fauna contains many species whose closest relatives are in the Palearctic fauna, and other species which have apparently arisen from Neotropical nuclei of evolving forms. The species described below is of this latter category.

Hydroptila denza, new species

Among some material from Mexico a speci-

men was encountered that is of the general type of *meralda* Mosely, but differs from it in a variety of characters: The claspers are little longer than the subgenital plate, the apex of the tenth tergite is deeply incised, and the apical blades of the aedeagus are wide and swordlike, Fig. 6*A*.

Male.—Length from front of head to tip of wings, 3 mm. Color moderately dark brown, the wings mottled with gray and brown. General structure typical for genus and scent cap ovate. Seventh sternite with a short, sharp apicomesal process. Genitalia as in Fig. 6. Ninth segment projecting freely from eighth segment, its internal portion rounded and only moderately produced, the apicolateral margin bearing a fingerlike lobe which appears sharp and spurlike from ventral view. Tenth tergite with lateral margins sclerotized, mesal portion membranous and deeply incised. Clasper of moderate length, ventral aspect with apex slightly widened, lateral aspect with apex much widened and trianguloid; apicolateral corner projecting as a small sharp point, apicomesal corner slightly angulate and a small sclerotized point just within it. Subgenital plate triangular, over two-thirds as long as clasper, and bearing a pair of setae near apex. Aedeagus, Fig. 6*A*, with base extremely long, extending internally through three full segments of a completely extended specimen; neck bearing a rufflike collar of membranous folds and a slender spiral process which encircles the aedeagus one and a half times; base of apex swollen, the apex beyond this divided into two parts, a long, bladelike, flattened, sclerotized process, and a tapering, straight style which bears the penis tube and which is membranous and corrugated at its base.

Holotype, male.—Hacienda Santa Engracia, Tamaulipas, Mexico, March 9, 1939.

Genus **Neotrichia** Morton

As is true of *Ochrotrichia*, *Mayatrichia*, and a few other genera, additional United States species of *Neotrichia* continue to follow patterns of general structure found in Central American forms. To date these genera are known only from the New World, and their distribution seems to indicate clearly that these genera originated in the Neotropics, and various species are spreading northward following the retreat of the glacial area.

Neotrichia numii, new species

The elongate and triangular claspers and the structure of the aedeagus indicate definite affinities between this species and *digitata* Mosely on the one hand and *collata* Morton on the other. From both this species differs in the extremely long, beaklike process of the subgenital plate, and the very dissimilar sclerotized processes at the apex of the aedeagus.

Male.—Length from front of head to tip of wings, 2.5 mm. Color entirely dark brown, the legs paler. General structure typical for genus. Genitalia as in Fig. 5. Ninth segment having an angulate internal portion, each side ending in a spurlike process; the dorsal portion is fused with the tenth tergite, the lateral portion is large and its apical margin is produced into a low, wide angle. Tenth tergite moderately narrow, rounded at apex and forming a simple, undivided mesal structure projecting above the other apical parts of the genitalia. Clasper elongate, lateral aspect tapering and curved at apex, ventral aspect having a broad, parallel-sided base narrowing suddenly to a short, pointed apex, heavily sclerotized and bearing only a few short setae. Bracteole, Fig. 5*C*, spatulate, pale, and bearing a series of long hairs on its ventral and apical margin, the base of the bracteole short and narrow, the apical portion broad and slightly curved dorsad. Subgenital plate unusually complex; the mesal portion, Fig. 5*B*, ends in a long beak which in lateral view is narrow and sharp, and in ventral view is expanded at apex into a platelike area bearing a hooked lateral process and a pair of mesal setae; this mesal part is joined ventrad with a large, convex lateral sclerite which narrows dorsad and appears to fuse with the inner margin of the tenth tergite. Aedeagus, Fig. 5*A*, elongate, the base tubular and narrowing to a long neck from the apex of which arises a stout spiral process encircling the aedeagus a little more than a complete turn; apex swollen at base, and divided at apex into a sharp spur bearing the penis and a lateral plate that is broad at base, slightly narrower at apex, and almost truncate at tip.

Holotype, male.—Lake George, Colo., in 11-mile canyon of the South Platte River, August 8, 1943, J. A. and H. H. Ross.

Neotrichia vibrans Ross

Neotrichia ranea Denning, Can. Ent. 79: 20. 1947. *New synonymy.*

Further study of this species indicates that there is considerable lateral movement of several parts of the genital capsule, and that this may result in considerable difference of appearance between one specimen and another. The widely expanded condition is shown in my own drawing (Ross, 1938, p. 120, Fig. 29), and a more contracted condition is illustrated by Denning in the description of *ranea*. Dr. Denning has kindly loaned me his type material for study.

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ZOOLOGY.—*An analysis of specific homonyms in zoological nomenclature.*[1]

RICHARD E. BLACKWELDER, U. S. National Museum.

In the systematic study of animals, which is the science known as systematics or taxonomy, the scientific names of the animals are at once an essential tool and a source of much confusion and discussion because of their vast number and the complexity of our system of using them. A branch of systematics has grown up which concerns itself entirely with these names and the principles to be used in applying them; this is nomenclature. Its principal aims are to formulate and establish systems under which each species can be given a distinctive name and to provide machinery to insure as great stability or permanence as possible to each of these names.

One of the difficulties which plague the taxonomist in his use of scientific names is the situation that arises when the same name is inadvertently given to two different species of animals. If a name is to be useful in exact science it must always refer to but one species, and always to the same species. Therefore, we cannot permit the use of one name for two or more species, and when duplicate names are found we must provide another name for one of the species. Identical names used for two or more species are called homonyms. They may be further classified by calling the older of the two usages the senior homonym and the younger one the junior homonym.

[1] Received April 2, 1948.

The discovery of homonyms very often results in a change of name for one of the species, and this type of change accounts for a large proportion of the annoying alterations of names that have given taxonomy a bad reputation among biologists. It is thus of special importance to taxonomists to study the problem of homonymy and find a way to protect names from this major source of instability.

The treatment of homonymy of specific names in zoological nomenclature is one of the oldest problems with which the writers of rules of nomenclature have had to deal, and it is one that has not been solved on any universal basis even after 75 years of code-building. It is therefore not unreasonable to reexamine the problem to present a possible new approach.

In the various nomenclatural codes that have been proposed, the treatment of the problem of homonymy differs widely. The reason for this divergent treatment is not clear, except on the assumption that none of them have given real satisfaction. It is therefore believed useful to examine the procedures that have been proposed heretofore and to analyze the requirements of a satisfactory system.

(I) The first method we will examine for dealing with homonyms is that prescribed by the International Rules of Zoological Nomenclature in articles 35 and 36. It is

the most direct and the simplest approach but may not be the one giving the most desirable results. This treatment is based on two principles: (1) "A specific name is to be rejected as a homonym when it has previously been used for some other species or subspecies of the same genus" (from article 35), and (2) "rejected homonyms can never be used again" (from article 36).[2] This is a simple and direct solution, and it has been reinforced by Opinion 83. Unfortunately the ramifications of nomenclature are not as simple as this rule, and names do not conform to a pattern of being irrevocably either "homonyms" or "not homonyms" at any given time.

This can be illustrated by diagrams of the eight major types of homonyms (Fig. 1). You may recognize in these diagrams your old friends *X-us albus* and *Y-us albus*. In these diagrams two genera are represented in parallel vertical columns. The passage of time as one reads down each diagram is indicated by the dates at the left, and the

[2] The term specific name is here used in its currently official meaning, in which the combination of the generic and the trivial names is a specific name. Article 2 holds that the scientific designation of a species is binomial, and it is therefore only the binomial combination that can be a homonym.

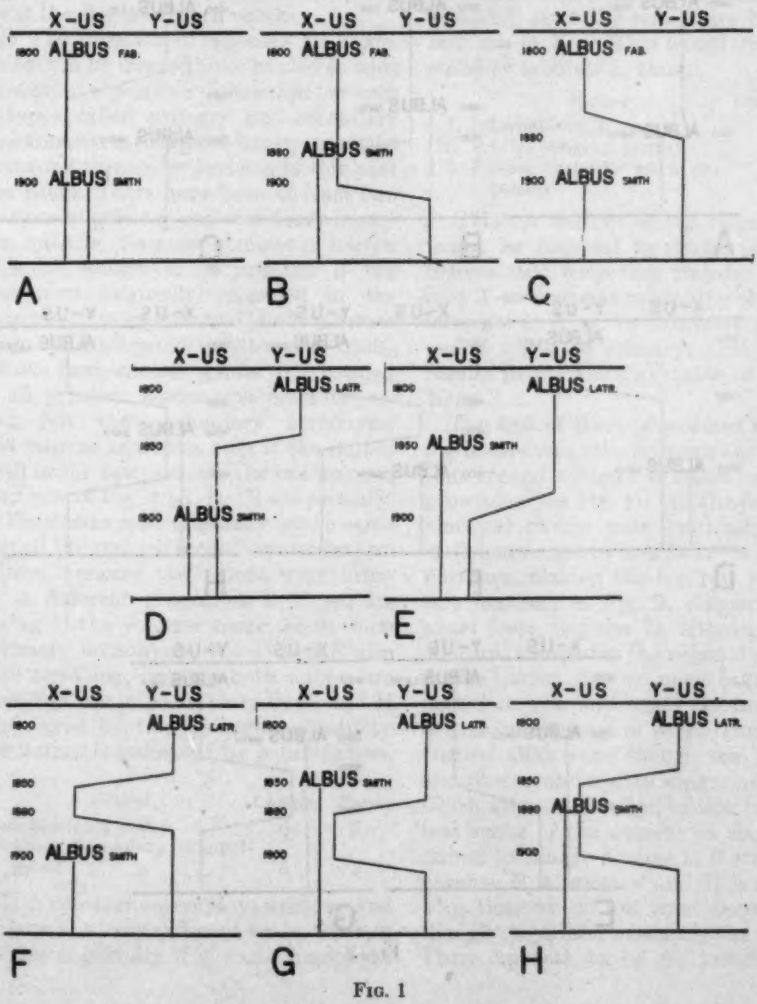

FIG. 1

subsequent history of each specific name is indicated by the solid line beneath it. The heavy horizontal line at the bottom represents the time at which the homonymy is discovered. In A, *albus* was proposed twice in *X-us*, producing unequivocal homonymy from 1900 on. B is just like A except for the later removal of one of the species to *Y-us*. It would be just the same if it had been the other name that was removed. In C the older name has been removed before the proposal of the second name. In D the two were originally proposed in separate genera, but by the time the second was proposed in *X-us*, the older name had been transferred to *X-us*, producing unquestionable homonymy. E is similar except that the transfer of the older name is later than the proposal by Smith. And F, G, H are the same as D and E except that the transfer of the older name to *X-us* was temporary—in F entirely prior to Smith, in G entirely subsequent to Smith, and in H partly before and partly after Smith.

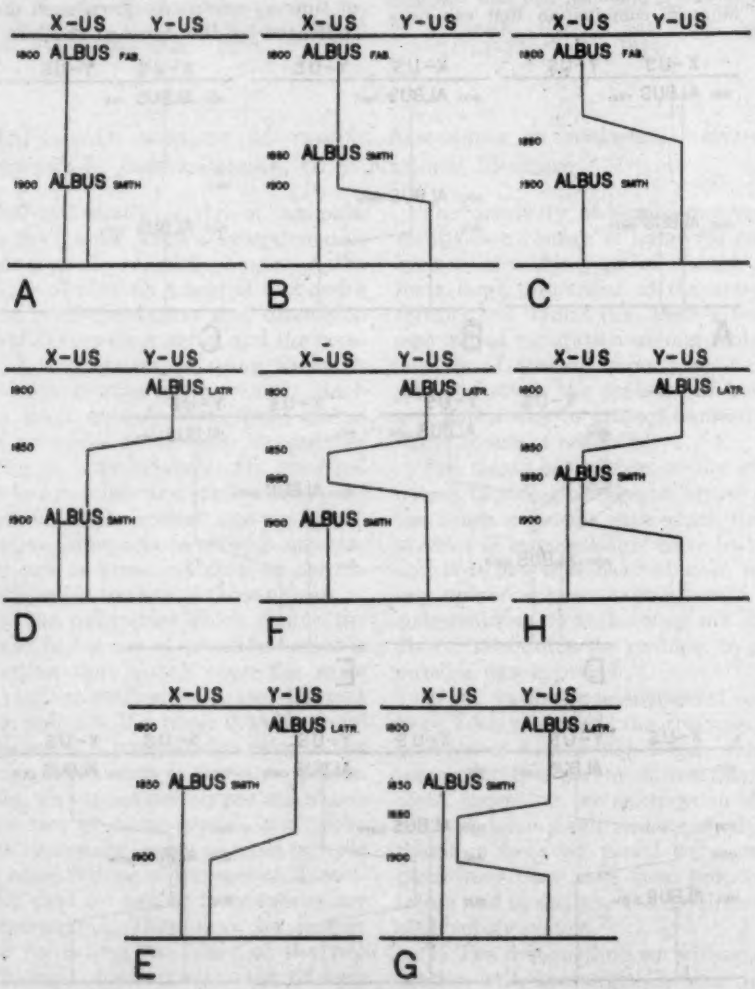

FIG. 2

Under the International Rules every one of these eight types of homonyms requires a change of name, because in every case there has been combined with *X-us* a name *albus* that is older than *X-us albus* Smith 1900. This is the rigid interpretation of the present wording of the Rules, which has been followed by many taxonomists but by no means by all.

Many taxonomists have felt that in some of these cases, such as diagram F in which the homonymy was of a temporary historical nature, it is not really necessary to replace the 1900 name. They have argued that a distinction of some sort should be made to prevent the change of such names.

(II) The question of whether all homonyms should be treated alike has led to wide discussion of a possible distinction between two types called primary and secondary homonyms, so that different treatment might be accorded them after revision of this part of the Rules. There have been at least two definitions of primary and secondary homonyms, but the one most commonly known is this. A homonym is primary if the names were originally proposed in the same genus; it is secondary if the two names occur in the same genus only through transfer of one from another genus. It is argued that all primary homonyms must be replaced, but that secondary homonyms should require replacing only if the names are still in the same genus. The examples in the top row of Fig. 1 (A, B, C) are primary, since the names were originally in the same genus; all the rest are secondary, under this definition, because the names were originally in different genera. A, B, C require replacing of the younger name, since these are primary homonyms, but D and E also require replacing, because both names are currently in use in *X-us*. Only F, G, and H can be saved by this procedure. Stability of the names is indicated by a tabulation, thus:

Method	*Change*	*Keep*
I. International Rules	8	0
II. Primary-Secondary (original genus)	5	3

(III) A third school employs primary and secondary in a very different sense. Here, a homonym is primary if it was a homonym at the time of its proposal, whether this fact was recognized or not; it is secondary if it was valid when proposed and became a homonym later by other action.

Again, the primary homonyms are treated as in the International Rules—they must be replaced. And secondary homonyms are considered to be such only as long as the two names remain in the same genus. In Fig. 2 we find the top two rows representing the primary homonyms under this definition. A, B, C, D, F, and H are primary, since the later name was already preoccupied by an older combination with *X-us*. But E, which is secondary, must also be replaced, since the names are both in current use in *X-us*. This would appear in the stability tabulation, thus:

Method	*Change*	*Keep*
I. International Rules	8	0
II. Pri-Sec (original genus)	5	3
III. Pri-Sec (validity when proposed)	7	1

(IIIa) A variant of the third procedure might be required by those persons who believe that *temporary* transfer of a name into *X-us* does not preoccupy the name for later use in *X-us*. In this case, A, B, C, D, and E would be primary. This would give results in the stability table of Change 5, Keep 3.

The first of these procedures for separating homonyms into primary and secondary (our second system) is based on two new principles (see Fig. 1): (1) The fact that the identical names were originally proposed in the same genus is held to be of first importance, making the top row primary. In this manner, in Fig. 3, diagram A is set apart from diagram D, although they are identical except for the original assignment of the names, yet we must take the same action in the two cases because there is actual homonymy in each. They must be treated alike even though one is primary and one secondary. In diagrams B and H, which also are identical except for the original genus of the names, we should be required to change a name in B and not in H because B is primary and H is secondary. This time we do not treat them alike, although they differ in exactly the same way. There appears to be no justification for

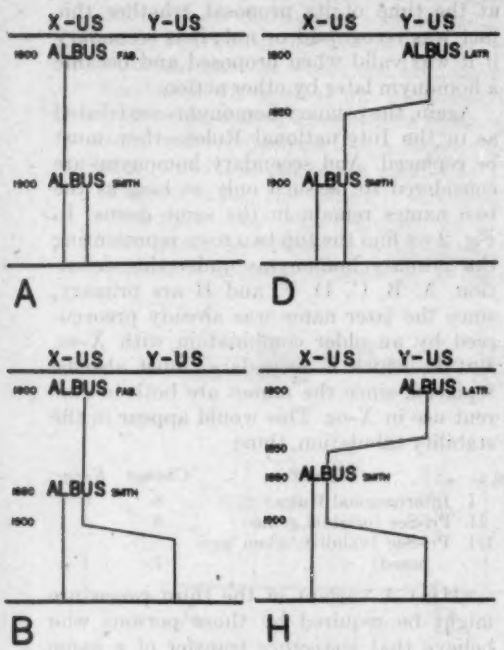

FIG. 3

these distinctions, and there also appears to be no basis for the principle of segregating homonyms on the basis of their original assignment. (2) A secondary homonym must be replaced only if the older name is still in the same genus at the time the homonym is discovered. There can be no question that the younger name in diagram D must be replaced, because there is active homonymy at the present time, but if in diagram H it is not necessary to rename the younger name, why must we do so in diagram B? Merely because of the accident of the original generic assignment of the older name? There appears to be no justification for the use of this principle either.

The second procedure for separating homonyms into primary and secondary uses another new principle (see Fig. 4). It places first importance upon the fact that Smith in 1850 (in E) was correct in believing that the name *albus* had never been used before in the genus *X-us*, whereas in D he failed in 1900 to recognize the older name. D is therefore called primary and E secondary. But in these cases if the older name had been later removed from *X-us* (H and G, in which H is called primary and G secondary) we would be required under this third procedure to replace the newer name in H (because it was a primary homonym) and would not be required to replace it in G (where it is secondary). Again we find that D (primary) and E (secondary) must be treated alike, whereas H (primary) and G (secondary) must be treated differently. There appears to be no reason for such a distinction.

In summarizing these last two procedures, it is apparent that there has appeared the new principle that a name may not be replaced unless the older name is still in the same genus when the homonymy is discovered, as in D and E of Fig. 4. But this principle is applied only to the class of secondary homonyms as variously defined. It would require a change in D and in E, and it would require a change in H but not G. There does not seem to be any reason why all types of homonyms should not be treated in this way. In other words, if there is no real justification for the distinction

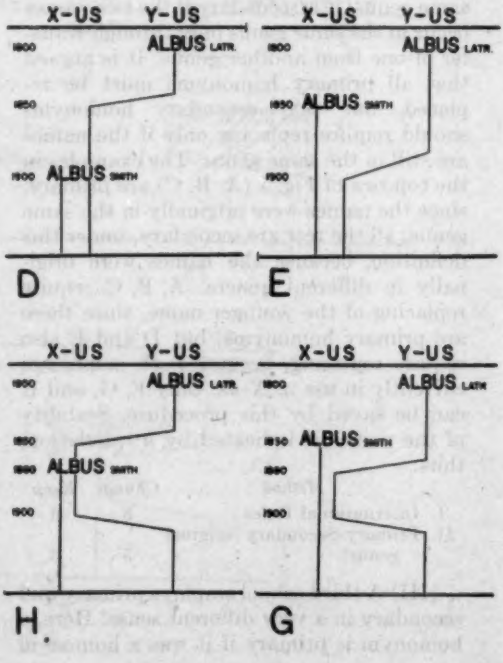

FIG. 4

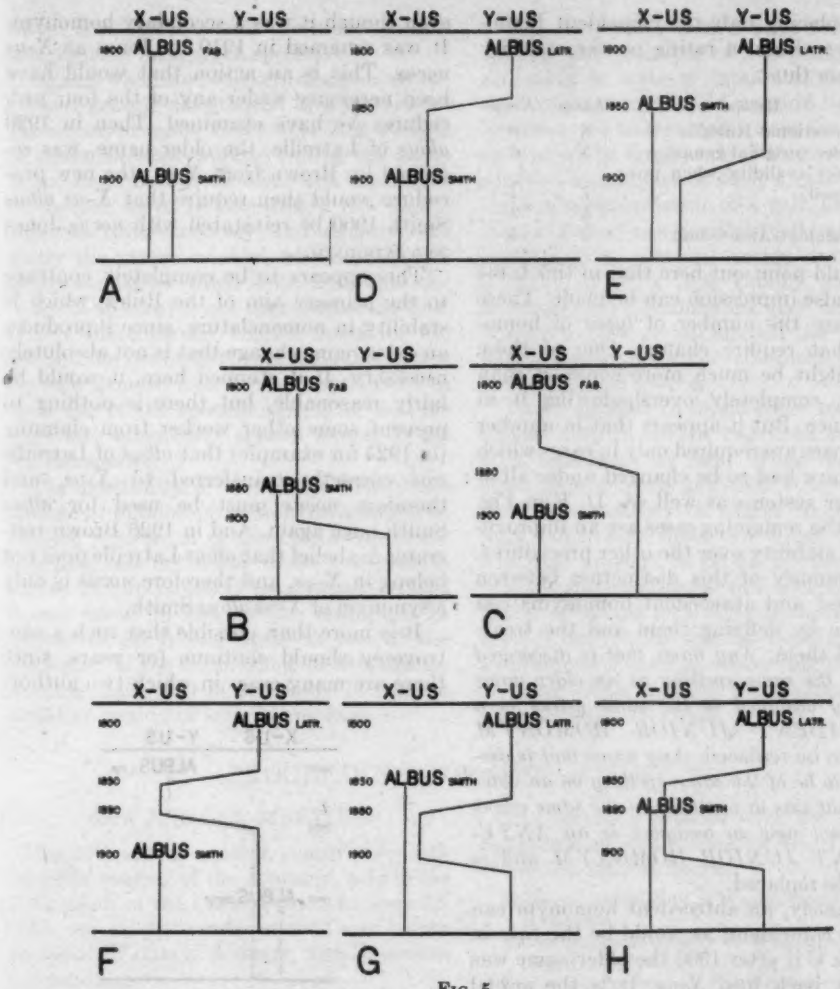

FIG. 5

between primary and secondary, why not judge both types on the same ground?

(IV) Now if we apply this new plan uniformly to all types of homonyms, we need new terms for the ones that are to be replaced and those that are not, to avoid confusion with primary and secondary. We are now interested, in the first place, in the situation as we find it at the time of discovery of the homonymy. (This time is represented by the heavy line across the bottom of each diagram.) The question to be asked is, Is there concurrent use of two names of identical spelling?

In Fig. 5, in A, D, and E two identical names are in use in the genus *X-us* at the present time—they occur together and are therefore *coincident* homonyms. In B, C, F, G, and H the names are not now in the same genus and are therefore homonyms only in an historical sense—only because of their antecedents. We may therefore term them antecedent homonyms.[3]

[3] Other terms may be thought more readily understood in these uses, such as *concurrent* and *historical* or *present* and *past*, but the need for any such terms would be eliminated in a new rule by calling only the first group "homonyms," eliminating the need for any term for the second group.

By replacing only the coincident homonyms, we obtain a rating on the stability tabulation thus:

Method	*Change*	*Keep*
I. International Rules	8	0
II. Pri-Sec (original genus)	5	3
III. Pri-Sec (validity when proposed)	7	1
IIIa.	5	3
IV. Coincident-Antecedent	3	5

I should point out here that in this table a very false impression can be made. These figures are the number of *types* of homonyms that require change. One of these types might be much more common than another, completely overshadowing it in importance. But it appears that in number IV, changes are required only in cases which would have had to be changed under all of the other systems as well (A, D, E in Fig. 5), and the remaining cases are an improvement in stability over the other procedures.

A summary of this distinction between coincident and antecedent homonyms can be made by defining them and the treatment of them. *Any name that is discovered to be of the same spelling as an older name currently assigned to the same genus is a COINCIDENT JUNIOR HOMONYM* and is to be replaced. *Any name that is discovered to be of the same spelling as an older name that was at one time in the same genus but is not now so assigned is an ANTECEDENT JUNIOR HOMONYM* and is not to be replaced.

Obviously, an antecedent homonym can become coincident, as would be the case in diagram C if after 1900 the older name was brought back into *X-us*. It is the actual state of affairs at the time of discovery of the homonymy that determines the type of homonymy and the action to be taken.

In some discussions of primary and secondary homonymy there has been proposed another new principle, which is a radical departure from the International Rules in that it requires the revival of a name previously suppressed as a homonym.

In Fig. 6, which represents a case of secondary homonymy in procedure II, *X-us albus* Smith, 1900, required replacing, even though it was a secondary homonym. It was renamed in 1910 by Jones as *X-us novus*. This is an action that would have been necessary under any of the four procedures we have examined. Then in 1920 *albus* of Latreille, the older name, was removed by Brown from *X-us;* the new procedure would then require that *X-us albus* Smith 1900 be reinstated with *novus* Jones as a synonym.

This appears to be completely contrary to the primary aim of the Rules, which is stability in nomenclature, since it produces an extra name change that is not absolutely necessary. If it stopped here, it would be fairly reasonable, but there is nothing to prevent some other worker from claiming (in 1925 for example) that *albus* of Latreille *was* correctly transferred to *X-us*, and therefore *novus* must be used for *albus* Smith once again. And in 1926 Brown reiterates *his* belief that *albus* Latreille does not belong in *X-us*, and therefore *novus* is only a synonym of *X-us albus* Smith.

It is more than possible that such a controversy should continue for years, since there are many cases in which two authors

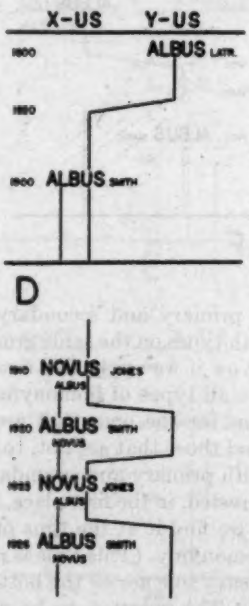

FIG. 6

have consistently used different generic assignments for a given species.

Again, when two workers disagree on the correct generic assignment of a species, as has occurred many times over long periods of years, the first worker, calling the genus *X-us*, finds that *X-us albus* is a secondary homonym, as in D, requiring a new name; whereas simultaneously and equally correctly the second worker, who believes the genus should be called *Z-us*, finds that the name *Z-us albus* is not preoccupied at 1900 and is therefore the correct name for the species. On the basis of their beliefs concerning the generic name, both are correct in their use of the specific names, so that we have two apparently correct names in use for one species.

The possibility of this result from a difference of opinion on generic assignment of another species, or of the correct name for a genus, can not occur under our present Rules. In procedure II as generally stated it can occur in five of the examples. In procedure III it can occur in two of the examples. If the conclusions of this discussion are made part of procedure IV, such a situation could not arise in any case.

The only point that I have seen raised against this principle of accepting a valid renaming in spite of later actions is that malicious transfer could provide the means for some one to rename any species desired, on a small or large scale. I have not found any one who knows of such a case of malicious misappropriation of a rule, and I consider it at best as a possibility of importance insufficient to warrant action designed to prevent it. If a case should occur, the International Commission has ample authority to take action against the offender, without adding to the complexity of our nomenclatural system.

There appears to be no other reasonable course than to accept the valid renaming of a homonym as final. There are other cases in which we find that strict priority gives less stability to names than a carefully controlled departure from priority. And this appears to be an opportunity to prevent the possible (or rather certain) confusion of having two valid trivial names in current use for one species, merely through a difference of opinion concerning the status of some other species which happens to have an identical name.

PROCEEDINGS OF THE ACADEMY

50TH ANNUAL MEETING

The 50th annual meeting, concurrently with the 353d meeting of the Academy, held in the Auditorium of the Cosmos Club, January 15, 1948, was called to order at 8:15 P.M. by the President, WALDO L. SCHMITT, with 55 persons in attendance.

The minutes of the 49th annual meeting were approved as published in the JOURNAL 37: 436–444. 1947.

The reports of several officers and of the Committees of Auditors and Tellers were read and accepted. These reports are recorded at the end of the minutes.

After the acceptance of the report of the Committee of Tellers, the President declared the following duly elected to the given offices:

FREDERICK D. ROSSINI, *President*,
C. LEWIS GAZIN, *Secretary*,
HOWARD S. RAPPLEYE, *Treasurer*,
FRANCIS M. DEFANDORF and WILLIAM N. FENTON, *Board of Managers to January 1951*.

The Secretary presented for the Affiliated Societies their nominations for Vice-Presidents of the Academy as follows:

Philosophical Society of Washington—WALTER RAMBERG
Anthropological Society of Washington—WILLIAM N. FENTON
Biological Society of Washington—JOHN W. ALDRICH
Chemical Society of Washington—CHARLES E. WHITE
Entomological Society of Washington—CARL F. W. MUESEBECK
National Geographic Society—ALEXANDER WETMORE
Geological Society of Washington—WILLIAM W. RUBEY
Medical Society of the District of Columbia—FREDERICK O. COE
Columbia Historical Society—GILBERT GROSVENOR
Botanical Society of Washington—RONALD BAMFORD
Washington Section of the Society of American Foresters—WILLIAM A. DAYTON

Washington Society of Engineers—CLIFFORD A. BETTS
Washington Section of the American Institute of Electrical Engineers—FRANCIS B. SILSBEE
Washington Section of the American Society of Mechanical Engineers—MARTIN A. MASON
Helminthological Society of Washington—AUREL O. FOSTER
Washington Branch of the Society of American Bacteriologists—LORE A. ROGERS
Washington Post of the Society of American Military Engineers—CLEMENT L. GARNER
Washington Section of the Institute of Radio Engineers—HERBERT GROVE DORSEY
Washington Section of the American Society of Civil Engineers—OWEN B. FRENCH

The Secretary was instructed by the members present to cast a unanimous ballot for these nominees.

The President announced the recipients of the Academy's Awards for Scientific Achievement for 1947 as follows:

In the Biological Sciences, no award made.

In the Engineering Sciences, HARRY W. WELLS, of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, in recognition of his distinguished upper-air research and organization of a world-wide network of ionospheric stations.

In the Physical Sciences, ROBERT D. HUNTOON, of the National Bureau of Standards, in recognition of his distinguished service in the advancement of electronics and its applications to other sciences and to modern ordnance.

The reports of three special committees were presented as a part of the program as follows: *The Journal*, by the Chairman of the Committee, RAYMOND J. SEEGER; *National Science Legislation*, by the Chairman of the Committee, A. T. MCPHERSON; *A Junior Academy of Sciences*, by the Vice-Chairman of the Committee, EGBERT H. WALKER.

The retiring President, WALDO L. SCHMITT, presented his address, *The Academy in Retrospect and Prospect*, then appointed Past Presidents EUGENE C. CRITTENDEN and OSCAR E. MEINZER to escort the incoming President, FREDERICK D. ROSSINI, to the chair. Dr. Rossini adjourned the meeting at 10:20 P.M.

REPORT OF THE SECRETARY

During the Academy year, January 16, 1947, to January 15, 1948, one person was elected to honorary membership and 45 persons were elected to regular membership, including 42 resident and 3 nonresident. Of these, 26 resident and 2 nonresident qualified for membership. Ten resident members, elected to membership January 12, 1948, were notified on January 13, but insufficient time has elapsed for their reply. Sixteen resident members and 4 nonresident members elected to membership in the preceding Academy year qualified during the present Academy year just ending. The new members were distributed among the various sciences as follows: 9 in botany, 8 in physics, 5 each in zoology and entomology, 4 each in chemistry and engineering, 2 each in paleontology, geology, anthropology, and plant pathology, and 1 each in biology, bacteriology, genetics, physiology, and ceramics.

Twelve resident and 3 nonresident members, having retired from the gainful practice of their professions, were placed on the retired list of members to enjoy all the privileges of active membership without further payment of dues.

The deaths of the following members were reported to the Secretary:

CHARLES S. BUTLER, Bristol, Tenn., on October 7, 1944.
GEORGES PERRIER, Paris, France, on February 16, 1946.
EDWARD A. GOLDMAN, Washington, D. C., on September 2, 1946.
Sir JAMES HARWOOD JEANS, Dorking, Surrey, England, on September 16, 1946.
WILLIS L. JEPSON, Berkeley, Calif., on November 7, 1946.
HENRY G. AVERS, Washington, D. C., on January 19, 1947.
HOWARD S. ROBERTS, 2d, Washington, D. C., on January 30, 1947.
CHARLES A. BROWNE, Washington, D. C., on February 3, 1947.
W. P. HAY, Bradenton, Fla., on May 26, 1947.
HARDEE CHAMBLISS, Washington, D. C., on June 1, 1947.
RUDOLF W. GLASER, Princeton, N. J., on September 4, 1947.
ROBERT H. LOMBARD, Worcester, Mass., on October 11, 1947.
DWIGHT W. WINDENBURG, Washington, D. C., on November 14, 1947.

Sir JAMES HARWOOD JEANS and General GEORGES PERRIER were honorary members.

On January 15, 1947, the status of membership was as follows:

	Regular	*Retired*	*Honorary*	*Patron*	*Total*
Resident.....	487	52	2	0	511
Nonresident....	131	26	15	0	202
Total.....	618	78	17	0	713

The net changes in membership during the past year are as follows:

	Regular	*Retired*	*Honorary*	*Patron*	*Total*
Resident	+ 8	+12	0	0	20
Nonresident	+ 9	− 2	−1	0	+ 6
Total	+17	+10	−1	0	+26

During the Academy year 1947 the Board of Managers held 9 meetings, with an average attendance of 18 persons. The following important matters were considered by the Board:

1. *Observance of the 50th Anniversary of the Academy.*—The President appointed a committee to look into the various ways in which the 50th Anniversary of the Academy might be observed and make recommendations to assist the incoming 1948 Board in its selection and carrying out of the observance. It was anticipated that this committee might render timely services inasmuch as the anniversary date, February 18, 1948, falls such a short time after the induction of the new Board of Managers.

2. *Preparation of an Illustrated Anniversary Edition of the "Red Book" or Directory.*—The Board of Managers authorized the publication of an Anniversary Edition of the Red Book, which is to include photographs of members of the Academy together with as complete a list as possible of the membership of the various scientific societies affiliated with the Academy, and to include the constitutions, bylaws and current lists of officers of the Academy and affiliated societies. The Board authorized the expenditure of $3,000 for the publication of the directory, with a leeway of $600 to cover unexpected charges, such as proofreading, etc.

3. *Consideration of a Monograph.*—A monograph on *The parasitic birds of Africa*, by Herbert Friedmann, was presented to the Board of Managers and recommended for publication by the chairman of the Monograph Committee. Estimates for the cost of publication were secured and the Board referred the manuscript to the Board of Editors for review and recommendation.

During the Academy year, seven meetings of the Academy were held as follows:

On February 20, 1947, HUGH L. DRYDEN, as retiring President, offered an address entitled *Exploring the fundamentals of aerodynamics.* Owing to unusually inclement weather the paper was read by title only.

On March 20, 1947, the 1946 Academy Awards for Scientific Achievement were presented to WALDO R. WEDEL, U. S. National Museum, for work in the biological sciences; to MARTIN A. MASON, Beach Erosion Board, for work in the engineering sciences; and GEORGE W. IRVING, Jr., Bureau of Agricultural and Industrial Chemistry, for work in the physical sciences.

On April 17, 1947, His Excellency, Mr. HERMAN ERIKSSON, Minister from Sweden, contributed a few remarks on Alfred Nobel and the Nobel prizes, introducing P. W. BRIDGMAN, of Harvard University, who addressed the Academy on *High pressures and their effects.*

On May 15, 1947, JAMES B. SUMNER, Cornell University, addressed the Academy on *The chemical nature of enzymes.*

On October 16, 1947, EDWARD A. DOISY, St. Louis University School of Medicine, addressed the Academy on *Vitamin K.*

On November 20, 1947, I. I. RABI, Columbia University, addressed the Academy on *The hyperfine structure of the hydrogens and other atoms.*

On January 15, 1948, the meeting of the Academy was devoted to the business of the 50th Annual Meeting and included the address of the retiring President, WALDO L. SCHMITT, entitled *The Academy in retrospect and prospect.*

The meetings were all held in the Assembly Hall of the Cosmos Club.

C. L. GAZIN, *Secretary*

REPORT OF THE TREASURER

Your Treasurer submits the following report concerning the finances of the Washington Academy of Sciences for the year ended December 31, 1947:

RECEIPTS

Dues, 1945	$ 30.00	
1946	75.00	
1947	3,167.00	
1948	70.00	$ 3,342.00

JOURNAL:		
Subscriptions, 1944	$ 6.00	
1945	6.00	
1946	6.00	
1947	735.09	
1948	557.84	
1949	3.38	1,314.31
Reprints, 1946	$ 515.41	
1947	672.73	1,188.14
Sales, 1947		178.07
Interest & Dividends		1,319.11
Directory		0.25
Cash received in connection with the transfer from the 6 percent to the 3.6 percent pref. stock of the Potomac Electric Power Co.		58.00
Payment of balance of principal on the Chicago Railways Bond		750.00
Received from Amer. Assoc. for Adv. of Sci.		479.00
Photostats and postage		2.32
Overpayment of dues		1.00
Total receipts, 1947		$ 8,632.20
Cash balance, Jan. 1, 1947		4,784.25
Total to be accounted for		$13,416.45

DISBURSEMENTS

	1946	*1947*	*Total*
Secretary's Office	$ 82.80	$ 224.95	$ 307.75
Treasurer's Office	21.30	236.78	258.08
Subscr. Mgr. & Custodian		48.36	48.36
Meetings Committee	40.25	327.10	367.35
JOURNAL:			
Printing & Mailing	333.83	3,451.27	3,785.10
Illustrations	50.90	516.44	567.34
Reprints	108.59	399.88	508.47
Office			
Ed. Asst.	20.00	270.00	290.00
Misc., postage, etc.	5.34	33.08	38.42
2—$1,000 Series G bonds		2,000.00	2,000.00
Grants in aid		479.00	479.00
1948 Red Book		292.00	292.00
Set of JOURNALS		100.00	100.00
Share in projector for Cosmos Club		27.85	27.85
Photostats		2.23	2.23
Refund, overpayment of dues		1.00	1.00
Totals	$663.01	$8,409.94	$ 9,072.95
Cash book balance, Dec. 31, 1947			4,343.50
Total accounted for			$13,416.45

RECONCILIATION OF BANK BALANCE

Balance as per cash book, Dec. 31, 1947			$ 4,343.50
Balance as per Amer. Sec. & Trust Co. Statement of Dec. 12, 1947		$4,972.67	
Receipts deposited since Dec. 12, 1947		397.69	
Total		$5,370.36	
Checks outstanding, as of Dec. 31, 1947			
No. 1018	$ 5.41		
1140	5.00		
1201	25.73		
1202	518.36		
1203	292.00		
1204	168.55		
1205	10.81		
1206	1.00	1,026.86	$ 4,343.50

INVESTMENTS

Washington Sanitary Improvement Co.		
Certificate No. 434—100 shares at $10.00	$1,000.00	
Certificate No. 435—100 shares at $10.00	1,000.00	
Certificate No. 527— 8 shares at $10.00	80.00	
Certificate No. 539— 1 share at $10.00	10.00	
Certificate No. 582—200 shares at $10.00	2,000.00	$ 4,090.00
Potomac Electric Power Co.		
Certificate No. TAO 1977—40 shares 3.6 percent pref. at $50.00		2,000.00
City of New York—3 percent (Transit Unification) Due—June 1, 1980		
Certificate No. D 20186	$ 500.00	
Certificate No. C 71038	100.00	
Certificate No. C 71039	100.00	
Certificate No. C 71040	100.00	800.00
First Federal Savings & Loan Ass'n.		
Investment account book		5,000.00
Northwestern Fed. Savings & Loan Ass'n.		
Certificate No. 1380	$4,500.00	
Certificate No. 1441	500.00	5,000.00
United States Government		
Series G Bonds—No. M 332990 G	$1,000.00	
M 332991 G	1,000.00	
M 332992 G	1,000.00	
M 332993 G	1,000.00	
M 1808741 G	1,000.00	
M 2226088 G	1,000.00	
M 2982748 G	1,000.00	
M 4126041 G	1,000.00	
M 5141346 G	1,000.00	
M 5141347 G	1,000.00	10,000.00
American Security and Trust Co.		
Savings Account		46.87
Total		$26,936.87
Cash balance 12/31/47		4,343.50
Total		$31,280.37
Total as of Dec. 31, 1946	$30,718.62	
Total as of Dec. 31, 1947	31,280.37	
	$ 561.75	

At the close of business on December 31, 1947, there were 50 members of the Academy who were in arrears, as follows:

No. of members	*In arrears for*
25	1 year
11	2 years
5	3 years
2	4 years
6	5 years
1	6 years
Total 50	

Probably at least half of these will regain the status of "member in good standing" eventually. However, the above tabulation shows plainly that a "house cleaning" is in order, and it is hoped that this work can be attended to early in 1948.

HOWARD S. RAPPLEYE, *Treasurer.*

REPORT OF AUDITING COMMITTEE

The accounts of the Treasurer of the Washington Academy of Sciences for the year 1947 were examined by your auditing committee on January 12, 1948.

The Treasurer's report was checked and found to be in agreement with the records. All disbursements had been authorized and were found to be supported by vouchers and cancelled checks. The securities of the Society were inspected and found to be in agreement with the list given in the report and to have all coupons attached that are not yet due.

Your Committee highly commends the Treasurer of the Academy upon the orderly and businesslike manner in which he has maintained the fiscal records. The Academy continues to be indebted to Mr. Rappleye for his conscientious and efficient performance of the arduous duties of his office.

FREDERICK D. ROSSINI, Chairman
AUSTIN H. CLARK
HAROLD E. MCCOMB

REPORT OF THE BOARD OF EDITORS

Volume 37 of the JOURNAL, for the year 1947, contained 448 pages in 12 issues, a gain of 16 pages over Volume 36 of the previous year, in this respect more nearly approximating the ideal of 500 pages recommended by previous editors. There were 59 papers distributed among the various sciences as shown in the table below.

These figures show an even poorer balance between the physical sciences and the biological sciences than the previous year. In 1946 about one-fourth of the pages of the JOURNAL were devoted to physical sciences including geology, whereas in 1947 the papers in the physical sciences used only about one-tenth of the pages of the JOURNAL. The disproportion reflects the production of the biologists and the activity of the freshman editor, Dr. STONE, who has been successful in procuring good papers. In 1947, moreover, the members of the Academy submitted over 50 percent of the papers published, an improvement over 1946 when less than half of the papers were submitted by our own members. A considerably larger number of papers was received than the editors felt merited publication in the JOURNAL. A slight decline in the number of papers published this year is offset by the space given to several papers, of which at least one has been widely noticed in this country and abroad. Anthropology continues to contribute a fair share of papers, and papers from its constituent disciplines may be expected to be a substantial part of the JOURNAL. Owing to the vigilance of Dr. HOFFMAN, who assumed responsibility for necrology, the number of obituaries procured was double that of 1946.

The JOURNAL and the new Board of Editors face the new year with confidence. Instead of the customary dearth of papers, the supply on hand will carry the JOURNAL through the first quarter of the year. Among the papers on hand and at the printer's are several in the physical sciences which the editors gathered during 1947 or which came to them through the activities of the Meetings Committee.

The JOURNAL faced a financial crisis in September, when the George Banta Publishing Co., through its representative, informed the Senior Editor, Dr. W. N. FENTON, that the costs of printing had increased to the extent that they had found it necessary to submit a new contract which, in effect, would increase the cost of printing the JOURNAL by about 31 percent. Dr. Fenton reported the matter to the Board of Managers, who referred the question to the Executive Committee, who, meeting October 13, 1947, recommended action, which the Board of Managers voted, October 20, to

Sciences	Number of papers, 1947	Number of pages, 1947	Percentage by pages, 1947	Number of pages, 1946	Percentage of pages, 1946
Biological	41	241	53.8	178.8	41.4
Physical	3	37	8.3	78.8	18.2
Anthropological	11	90	20.1	114.0	26.4
Geological	2	12	2.7	24.2	5.6
Other (History of Science)	2	19	4.2	9.5	2.2
Obituaries, Proceedings, etc.	—	45	10.0	23.0	5.3
Index	—	4	0.9	4.0	0.9
Totals	59	448	100.0	432.0	100.0

increase the budget for the JOURNAL by $225 to meet the increase in cost of publication for the remainder of the year, and authorized Dr. FENTON to sign the new contract with the George Banta Publishing Co. for printing the JOURNAL.

The original 1947 budget provided $4,000 for printing and mailing, to which was added $225 (mentioned above), $300 for editorial assistance, and $50 for miscellaneous office supplies and postage, bringing the total to $4,575. To this is to be added the charges to authors, which amounted to $936.38, making a grand total of $5,511.38.

The disbursements for the JOURNAL have been:

Printing and mailing	$3,831.14
Illustrations	532.95
Reprints	473.64
Editorial assistance	295.00
Office, miscellaneous	42.31
Total	$5,175.04

To recapitulate, the total cost of the printing bills was $4,837.73. From this may be subtracted $936.38, the amount charged to authors for reprints, excess illustrations, and excess typesetting charges. Thus the net cost to the Academy of printing the JOURNAL was $3,901.35.

It should be noted that on several items the Editors are well within their appropriation and that, despite the rise in printing costs at the end of the year, they were able to get by without the supplemental appropriation.

The Board of Editors wishes to acknowledge the cooperation of the Board of Managers and the officers of the Academy. The Associate Editors met with the Board of Editors early in the year and worked out a procedure for handling manuscripts in special fields, for reading galley proofs, and for consultation, in all of which the Associate Editors have supported the Board of Editors ably and willingly. Dr. R. E. BLACKWELDER supplied for Dr. STONE during the latter's field work in Alaska, and special thanks are due to Mr. PAUL H. OEHSER, our editorial assistant, for taking over administrative duties during the summer months while Dr. FENTON was away teaching. Mr. OEHSER's very considerable specialized knowledge and his genuine interest in the continual improvement of the JOURNAL far exceed the implication of his title.

The Editors also wish to cite Mr. IRWIN H. WENSINK, Washington representative of the George Banta Publishing Co., for his help in maintaining the continuity and high standard of the JOURNAL and for the courteous way that he conducted negotiations for a new contract for his company. We do not think it entirely flattery when he tells us that the Academy's editorial set-up has come to be a model which his company recommends to other learned bodies.

WILLIAM N. FENTON
JAMES I. HOFFMAN
ALAN STONE

REPORT OF THE CUSTODIAN AND SUBSCRIPTION MANAGER OF PUBLICATIONS

SUBSCRIPTIONS:

Nonmember subscriptions in the United States	131
Nonmember subscriptions in foreign countries	75
Total	206

INVENTORY OF STOCK AS OF DECEMBER 31, 1947:

Reserve Sets of the JOURNAL:	
Bound Volumes 1–29 and unbound Volumes 30–37	1 set
Unbound Volumes 1–37	3 sets
Unbound Volumes 11–37	6 sets
Unbound Volumes 16–37	11 sets
Miscellaneous numbers of the JOURNAL	18,911
Total numbers in the Reserve Sets	8,070
Grand total of back numbers	26,981

The only important change that has taken place during the year 1947 was the resignation of FRANK M. SETZLER as Custodian and Subscription Manager of Publications. Mr. SETZLER was forced to hand in his resignation toward the end of this year because of his leaving the country for an extended field trip. To fill this vacancy, I was appointed at the 411th meeting of the Board of Managers held on October 20, 1747. Mr. SETZLER has admirably filled this position for five years, and during this tenure of office he has organized the operations and records in a most efficient manner, so that when I took over this position I found everything in perfect order and all information readily accessible. I feel that Mr. SETZLER deserves to be highly commended for the excellent way in which he has run this office.

SALES AND EXPENDITURES:

During the year no complete sets were sold, but the sale of individual volumes and numbers

has continued, 24 volumes and 115 numbers having been sold. One complete set (Vol. 1–36) was purchased from one of the members of the Academy.

Income from Sales	
Miscellaneous numbers	$178.07
Expenditures	
Set of JOURNAL Vol. 1–36	$100.00*
Postage and office expenses	48.36
1947 Budgetary allotment	$ 50.00†
Enexpenditures for 1947	48.36
Unexpended balance	$ 1.64

* Deducted from special fund earmarked for purchase of volumes and numbers needed to form complete reserve sets.

† This does not include the additional $50 that was added to the budget allotment by vote of the Executive Committee for the purpose of carrying out a campaign to increase the present subscription list. This money was not expended in 1947.

HARALD A. REHDER, *Custodian and Subscription Manager of Publications*

REPORT OF THE COMMITTEE OF TELLERS

A total of 325 envelopes were delivered to the Secretary. The count of valid ballots showed the following officers were elected:

President, FREDERICK D. ROSSINI
Secretary, C. LEWIS GAZIN
Treasurer, HOWARD S. RAPPLEYE
Board of Managers to January 1951, FRANCIS M. DEFANDORF and WILLIAM N. FENTON

ANNA E. JENKINS, *Chairman*
MIRIAM L. BOMHARD
REGINA FLANNERY

REPORT OF SPECIAL COMMITTEE ON LEGISLATION (ABSTRACT)

The Committee on Legislation, composed of J. E. GRAF, W. W. RUBEY, and A. T. MCPHERSON, reported on recent and pending legislation in three phases of Government activity, each of especial interest and importance to science. Unusual possibilities for the advancement of science were seen in the international exchange of scholars and information provided by the Fulbright Foreign Scholarship Act (Public Law 584, 79th Congress) and by the proposed Information and Educational Exchange Act of 1948 (HR 3342, January 7, 1948). Funds for the program under the former act are in foreign currencies derived from the sale of surplus war property abroad. The latter bill which was expected to be passed at an early date contains provision for the dollars needed to send American scholars abroad and will extend the international exchange of scholars to countries in which there was no surplus property.

The second phase of legislative action reported on was that concerned with the future of the synthetic rubber industry. The Committee felt that the most important consideration for future national security regarding rubber lay in establishing an adequate research and development program, entirely apart from any production program. The cost of such a program would be less even than the cost of maintaining the unused plants in standby condition.

The third subject dealt with by the Committee was that of the National Science Foundation. At the time of the report, it was thought that a compromise bill acceptable to both the Congress and the Administration would be introduced soon.

The recent report of the President's Scientific Research Board was reviewed and was compared with a similar study made by Rosa after World War I.* The fact that many of the recommendations regarding the scientific program of the Government made in the Rosa report are similar to those in the current report was cited by the Committee in support of their recommendation that the Academy give serious and sustained attention to legislation relating to science.

A. T. MCPHERSON, *Chairman*

REPORT OF THE SPECIAL COMMITTEE ON A JUNIOR WASHINGTON ACADEMY OF SCIENCES

Dr. WALDO L. SCHMITT, President of the Washington Academy of Sciences in 1947, appointed a committee on junior academies of science consisting of Austin H. Clark, Chairman, E. H. Walker, Vice Chairman, and Frank Thone, and requested it to study the subject and make recommendations to the Washington Academy of Sciences. The following is the report of the vice-chairman based upon the results of the study as given in his talk at the 50th

* *Expenditures and revenues of the Federal Government*, by EDWARD B. ROSA. Publication No. 1518. Reprinted from "Taxation and Public Expenditures," Vol. 95 of the Annals of the American Academy of Political and Social Science, Philadelphia, May 1921.

annual meeting of the Washington Academy on January 15, 1948.

The growing interest in the early recognition and encouragement of potential scientists has found expression in the development of organizations working with and for these young scientists. Their activities are centered largely on the approximately 15,000 science clubs in the secondary schools throughout the country. Assisting in the coordinating of these clubs is Science Clubs of America, administered by Science Service, Inc., Washington, D. C. An important activity of this coordinating organization is the conducting of the annual Science Talent Search for the Westinghouse Science Scholarships. Scholarships totaling $11,000 are distributed among the 40 winners on the basis of a nation-wide examination. In 11 states additional awards are granted to local winners in this same examination, this usually under the auspices of the state junior or senior academies of science.

Junior academies of science exist in more than 30 states. The first one was formed in Illinois in 1919. These organizations provide to the young scientists and their sponsors, mostly organized into school science clubs, (1) valuable training through cooperative endeavors; (2) association with other young scientists and with adult scientists; (3) incentives to the students through exhibits, fairs, and congresses, to engage in creative activities; (4) incentives and assistance to the adult sponsors; (5) insight into senior scientific organizations and their activities; and (6) opportunities to take an active part in adult scientific projects.

Membership in these junior academies usually consists of the science clubs as chapters and their members as individuals. They are variously financed, the funds coming from dues paid by the chapters or by the members, or both, and subsidies by senior academies, teacher organizations, sponsors, friends, commercial organizations, etc. Sums run from about $20 to $400 annually. Additional services and facilities are often provided by associated and sponsoring organizations.

The Junior academies of science are usually governed by committees of the senior academies and of the school sponsors of the clubs. They function best where there is an experienced and active adult leader on both committees or at least actively supported by them.

These junior academies, besides assisting in the conduct of the science clubs' activities, provide stimulating and coordinating publications, sectional meetings, an annual state congress, usually in connection with the annual state academy meeting, with exhibits, fairs, trips, talks, etc., and awards of various kinds. They often enlist the aid of juniors in various senior scientific projects where such is appropriate.

The organization of a Junior Washington Academy of Science is favored by local individuals and organizations engaged in junior scientific work. The head of the science work in the public schools and the teacher-sponsors of the science clubs believe it would be a spur to their efforts and could provide valuable facilities they are otherwise unable to obtain. Science Clubs of America would be glad for such an Academy to take over its responsibilities in the annual science fair, an activity which it has previously assumed in the absence of other suitable organizations to do so. It would be glad to assist in the selection of the best science talent in this area for awards in addition to the national Westinghouse Science Scholarships.

This committee's investigation of the local organizations and individuals who might be interested in this project is incomplete. More work should be done in this field before a final plan of organization is prepared. There should be careful investigation of the activities of the Virginia Junior Academy of Science, centered in Charlottesville, in order to coordinate the considered activities of a Junior Washington Academy of Sciences with those of this nearby organization working within the greater Washington area. We have had a preliminary meeting with officers of the Maryland Academy of Sciences in Baltimore and find that our activities would supplement theirs in the adjacent portion of Maryland, with which we might be concerned, and that cooperation with that organization would be highly desirable and welcomed. Their junior academy is temporarily suspended for lack of a director, but much junior work is being carried on along with their program of interpretation of science. The different emphases and perspectives of the Maryland and of the Washington Academies of Science would find common ground through this proposed Junior Washington Academy of Sciences.

We, therefore, recommend that the Board in control of the Washington Academy of Sciences continue this committee with new or augmented personnel and instruct it to report at the April meeting of the Academy definite and detailed plans for organizing a Junior Washington Academy of Sciences with proposals for implementing this plan.

EGBERT H. WALKER, *Vice Chairman*

REPORT OF SPECIAL COMMITTEE TO CONSIDER VARIOUS MATTERS PERTAINING TO THE JOURNAL AND ITS IMPROVEMENT

The report of this committee was included in the published Proceedings of the Academy, 414th Meeting of the Board of Managers: This JOURNAL **38** (2): 79–80. Feb. 15, 1948.

Submitted by C. LEWIS GAZIN, *Secretary*

417TH MEETING OF BOARD OF MANAGERS

The 417th meeting of the Board of Managers, held in the Cosmos Club, April 12, 1948, was called to order at 8:05 P.M. by the President, Dr. F. D. ROSSINI. Others present were: H. S. RAPPLEYE, N. R. SMITH, H. A. REHDER, W. W. DIEHL, W. RAMBERG, T. D. STEWART, C. E. WHITE, A. WETMORE, W. A. DAYTON, C. A. BETTS, M. A. MASON, L. A. ROGERS, C. L. GAZIN, and, by invitation, H. E. McCOMB, R. J. SEEGER, A. STONE, J. E. GRAF, and F. H. H. ROBERTS, JR.

The following appointments were announced by the President: *Committee on the Index of the Journal:* W. N. FENTON, Chairman, J. I. HOFFMAN, M. C. MERRILL, H. A. REHDER, PAUL H. OEHSER (consultant). *Committee on Functions and Policies of the Academy:* E. C. CRITTENDEN, Chairman, A. H. CLARK, W. A. DAYTON, M. A. MASON, L. W. PARR, F. B. SILSBEE.

The Chairman of the Meetings Committee announced that Prof. PHILIPP FRANK, of Harvard University, would speak at the April meeting of the Academy.

The Chairman of the Special Committee to consider certain revisions of the Bylaws of the Academy and Standing Rules of the Board of Managers, Dr. WALTER RAMBERG, read the following report:

The Committee has considered means of revising the Standing Rules of the Board of Managers in order to provide greater continuity in the Standing Committees of the Board. The Committee recommends the following revisions for this purpose:

Standing Rules

Section 3, third sentence, replace by: "The Committee on Membership, Meetings, Grants-in-Aid for Research, and each of the Subcommittees of the Committee on Awards for Scientific Achievement shall include, if possible, at least two members reappointed from the preceding year. The Committee on Monographs shall have six members, each appointed for 3 years at the rate of two each year. At least three members of the Committee on Monographs shall be past editors of the JOURNAL, if possible."

In addition the Committee recommends the following revision in the Standing Rules in order to describe more accurately the duties of the Committee on Awards for Scientific Achievement:

New Section 8, second sentence, replace by: "A candidate must be a member of the Washington Academy of Sciences or a resident member of one of the affiliated societies, and shall not have passed the 40th anniversary of the date of his birth by the end of the calendar year for which the award is made; recommendations by the Committee must reach the Board of Managers not later than the meeting preceding the Annual Meeting of the Academy in January."

The Chairman of the Committee on Science Legislation, JOHN E. GRAF, reported that Senate Bill 526 had been vetoed by President Truman but that Senator Smith of New Jersey was sponsoring S3285, introduced March 25, which would overcome some of the objections raised to the previous bill.

The president announced that the results of the study to be made by the Special Committee appointed to consider the policy and functions of the Academy were to be available by the end of the calendar year and to be published in the JOURNAL as a matter of permanent record and in order to bring them to the attention of the membership of the Academy.

Changes in the Standing Rules of the Board of Managers introduced at the 416th meeting were approved as follows:

Section 2

After c. iv., insert:

"v. Committee on Awards for Scientific Achievement."

"vi. Committee on Grants-in-aid for Research."

Section 3

Replace first sentence by: "There shall be six STANDING COMMITTEES, as follows: Executive

Committee, Committee on Meetings, Committee on Membership, Committee on Monographs, Committee on Awards for Scientific Achievement, Committee on Grants-in-Aid for Research."

Section 4, first sentence:

In place of "or acting President," insert "President-Elect" (providing the Academy approves of the new office of President-Elect).

Following Section 6, insert:

7. The COMMITTEE ON MONOGRAPHS shall receive for review and recommendation regarding publication such monographs as may be submitted to the Academy, preference being given to members of the Academy.

8. It shall be the duty of the COMMITTEE ON AWARDS FOR SCIENTIFIC ACHIEVEMENT of recommending one candidate each for the Biological Sciences, the Engineering Sciences, and the Physical Sciences. A candidate shall not have passed the 40th anniversary of the date of his birth by the end of the calendar year for which the Award is made; recommendations by the Committee must reach the Board of Managers not later than the meeting immediately preceding the annual meeting of the Academy in January. Each recommendation to the Board must be accompanied by a written supporting statement giving the necessary information concerning the candidate, together with a citation covering not over 80 spaces, as "in recognition of his distinguished service in ——(80 spaces)——."

9. The COMMITTEE ON GRANTS-IN-AID FOR RESEARCH shall review applications for grants-in-aid from such funds as may be at the disposal of the Board of Managers for this purpose.

Renumber:

present Section 7 as new Section 10
present Section 8 as new Section 11
present Section 9 as new Section 12
present Section 10 as new Section 13
present Section 11 as new Section 14
present Section 12 as new Section 15.

The meeting was adjourned at 9:35 P.M.

C. LEWIS GAZIN, *Secretary.*

Obituary

GEORGE ROGERS MANSFIELD, retired geologist of the U. S. Geological Survey, member of the Geological Society of Washington, and its 39th President in 1930, died at the home of one of his daughters, Mrs. John W. Carroll, at Swarthmore, Pa., on Sunday, July 11, 1947. He was born August 30, 1875, in Gloucester, Mass. At Amherst College he received the B.S. degree and membership in Phi Beta Kappa in 1897, and the M.A. degree in 1901. From 1897 to 1903 he was science teacher at Central High School in Cleveland, Ohio. At Harvard University he received the Ph.D. degree in 1906 and was instructor in geology from 1906 to 1909. At Northwestern University he was assistant professor in geology from 1909 to 1912. He worked during the summers of 1910 to 1912 for the U. S. Geological Survey in Idaho. In 1913 he joined the permanent staff as geologist and was placed in charge of phosphate investigations, which he carried on for many years. In 1922 he was made chief of the Section of Nonmetalliferous Deposits, in 1921 editor of geologic maps, and in 1927 chief of the Section of Areal and Nonmetalliferous Geology. He retired in 1943.

Dr. Mansfield's contributions to geology over a period of 36 years (1906–42), include 109 titles, of which Professional Paper 152: *Geography, geology, and mineral resources of a part of southeastern Idaho*, published in 1927, may be cited as an example of his outstanding competence in investigation, description, discussion and solution of the areal, physiographic, stratigraphic, structural, and economic problems encountered in the detailed study of an area (in this case of some 2,200 square miles). Other publications of the Survey of which he was either author or joint author described the phosphates of Florida, the greensands of New Jersey, the nitrates of California, Texas, Idaho, and Oregon, and the potash deposits of Texas and New Mexico. His other contributions appeared in many publications, mainly those of the Geological Society of America, American Association of Geographers, the American Journal of Science (of which he was associate editor from 1938 to 1945), the Journal of Geology, Washington Academy of Sciences, Industrial and Engineering Chemistry, Economic Geology, Science, Proceedings of Section E of the American Association for the Advancement of Science.

He was a member of the National Research Council 1925 to 1934 and chairman of the committee on tectonics from 1924 to 1934, a fellow of the Geological Society of America, and a member of the American Institute of Mining

and Metallurgical Engineers, the Society of Economic Geologists, the American Geophysical Union, the Washington Academy of Sciences (vice president 1931), and the Cosmos Club.

He is survived by his wife, Adelaide Clafin Mansfield; three sons, Harvey C. Mansfield, a professor of political science at Ohio State University, Dr. James S. Mansfield, of Cambridge, Mass., and Robert H. Mansfield, of Caracas, Venezuela; two daughters, Mrs. George W. Patterson, of Morton, Pa., and Mrs. John W. Carroll, of Swarthmore, Pa.; and twelve grandchildren.

RALPH W. RICHARDS